

# New York State Museum

JOHN M. CLARKE Director

Bulletin 96

GEOLOGY 10

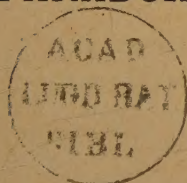
## GEOLOGY

OF THE

## PARADOX LAKE QUADRANGLE, NEW YORK

BY

IDA H. OGILVIE



|                                                                 | PAGE |                                                                 | PAGE |
|-----------------------------------------------------------------|------|-----------------------------------------------------------------|------|
| Introduction .....                                              | 461  | Glacial deposits and drainage<br>modifications .....            | 469  |
| Topography and geology of the<br>Adirondacks .....              | 461  | General geology .....                                           | 478  |
| Recent geologic work .....                                      | 463  | Summary of evidence of rel-<br>ative age of igneous rocks ..... | 487  |
| Location and topography of the<br>Paradox Lake quadrangle ..... | 464  | Petrography .....                                               | 492  |
| Physiography and glaciology ...                                 | 465  | Petrography of sedimentary<br>rocks .....                       | 493  |
| Cambric drainage lines .....                                    | 465  | Petrography of igneous rocks .....                              | 495  |
| Penepains .....                                                 | 468  | Summary and conclusions ...                                     | 502  |
| Summary of the preglacial ero-<br>sion history .....            | 468  | Economic geology .....                                          | 503  |
| Age of lower base-level .....                                   | 469  | Index .....                                                     | 507  |

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SIR: I beg to transmit for publication as a bulletin of the State Museum a paper by Dr Ida H. Ogilvie on *The Geology of the Paradox Lake Quadrangle*.

Very respectfully yours

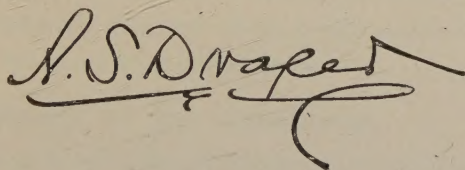
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COMMISSIONER'S ROOM

*Approved for publication Oct. 27, 1904*

A handwritten signature in dark ink, reading "A. S. Draper". The signature is written in a cursive style with a long, sweeping underline that extends to the right.

*Commissioner of Education*





# New York State Museum

JOHN M. CLARKE Director

Bulletin 96

GEOLOGY 10

## THE GEOLOGY OF THE PARADOX LAKE QUADRANGLE, NEW YORK

### PART 1

#### INTRODUCTION

The field work upon which this paper is based was carried on during the summer of 1901. The results were elaborated in the laboratories of Columbia University during the winter of 1901-2, and in the summer of 1902 a general survey was made embracing the surrounding region beyond the limits of the report proper, together with a resurvey of certain critical points within the area in question. The work was directed by Prof. J. F. Kemp of Columbia University, to whom the most cordial thanks are due, and whose kindly interest both in field and laboratory has been of constant value.

#### TOPOGRAPHY AND GEOLOGY OF THE ADIRONDACKS

The Adirondacks form the most conspicuous topographic feature of northern New York. They include an area of some 10,000 square miles, roughly circular in outline, and almost surrounded by the St Lawrence, the Mohawk and the Hudson-Champlain valleys. Topographically the region may be divided into a central mass of high peaks with deep and narrow intervening valleys, and a surrounding area of lower hills with broader valleys and gentler slopes. Geologically the central mass consists of plutonic rocks of the gabbro family; the surrounding hills, of various types of gneiss. In the gneissic area limestone prevails in the valleys, and the limestone often extends up the valleys of the central plutonic core. Surround-

ing the crystalline area and outside of the Adirondacks proper is a plain cut on gently dipping Palaeozoic rocks. A few outlines of these Palaeozoics within the crystalline area indicate their former extent.

The Adirondack region has been extensively faulted. Some of these faults are quite recent (though all are preglacial) and form conspicuous topographic features. The most recent faults run in general northeast-southwest directions, and were accompanied by block tilting toward the east. Drainage lines have established themselves along the fault lines, the tributaries on opposite sides working against a steep cliff or a gentle slope respectively.

The trellised drainage of the Adirondacks has been noted by Professor Brigham.<sup>1</sup>

He showed from a study of several topographic maps that the main drainage lines lay along northeast-southwest valleys, and that of the tributaries, the eastward flowing ones had much the longer courses. The main drainage lines lie along the fault lines, and as the tilting has been toward the southeast, the tributaries flowing in that direction have the advantage over those flowing westward, which have to cut back against the faces of steep fault cliffs.

This block tilting has led to the production of a most striking feature in the landscape, namely, the peculiar form of the mountains. The almost universal shape of the higher hills is that of a truncated cone, with steep, often precipitous faces toward the northwest and long gentle slopes toward the southeast. There are some lower summits which owe their existence to the erosion of the soft limestone from the valleys, such mountains of course presenting normal erosion outlines. But the prevailing type is the faulted one.

This general type of mountain, accompanied by this kind of drainage, is the predominant one on the Paradox Lake quadrangle, irrespective of rock type. Owl Pate, Bald Pate, Catamount and many others within the anorthosite area have this outline, while among the gneisses Knob, Bear and others show the same form. The valleys at the foot of the steep fault cliffs often contain small rock-bound lakes.

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<sup>1</sup>Am. Geol. 1898. 21:219.



Plate 1

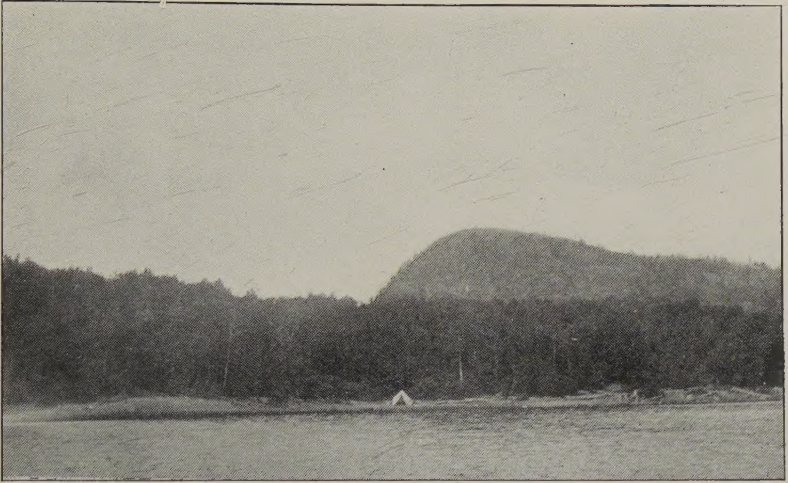


Fig. 1 Bear mountain from Crane pond. A fault block, with cliff facing west and flat tilted eastward. Granite gneiss



Fig. 2 View from Bear Pond mountain. Chilson lake in the foreground lies in a wide limestone valley. In the background is a narrow valley whose western side is the fault cliff of Knob mountain





In the Adirondacks the most important problems today belong to two distinct departments of geology. One series of problems is concerned with the physiography and glacial phenomena, on which no detailed work has been hitherto done; the other series of problems are concerned with the gneisses, both as to relative age and as to origin.

### Recent geologic work

The first geologic report on the Adirondacks was that of E. Emmons in 1842. Since that time little was attempted until about fifteen years ago, when Prof. J. F. Kemp took up the task of unraveling the complicated structure of the eastern part of the region, while Prof. C. H. Smyth jr in the west and Prof. H. P. Cushing in the north directed their efforts to those portions. The combined work of these three investigators has led to interesting results in the interpretation of the region as a whole.

The greater part of the region covered by the Paradox Lake quadrangle was described in a preliminary way in Professor Kemp's early reports.<sup>1</sup>

The southern portion of the region was treated by Professor Kemp and D. H. Newland.<sup>2</sup>

The preliminary work was done without the aid of good maps, and it was not thought advisable to begin detailed investigation until the United States Geological Survey sheets were published. Some of these topographic maps have recently appeared, and with one of them as a basis it was hoped that by a careful and detailed study of a relatively small area some facts might be added to those already accumulated. The purpose of this paper is to treat in detail of the geology, both glacial and deep seated, of the area covered by the Paradox Lake quadrangle, thus making a beginning of the interpretation of Adirondack glacial deposits, and a contribution to the solution of the problems of the gneisses.

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<sup>1</sup>See Preliminary Reports on Geology of Essex County in N. Y. State Geologist An. Rept for 1893 and 1895.

<sup>2</sup>Preliminary Report on the Geology of Washington, Warren and parts of Hamilton County, N. Y. State Geologist An. Rept for 1897.

**LOCATION AND TOPOGRAPHY OF THE PARADOX LAKE  
QUADRANGLE**

The Paradox Lake quadrangle covers the southeastern part of the Adirondacks. It is for the most part within the gneissic area but in its northeastern portion includes some of the outlying peaks of the central plutonic area. The highest peaks in the Adirondacks rise to upwards of 5000 feet; the highest on the Paradox quadrangle is 2941, the region being thus among the foothills. The southern and eastern portions are in the gneissic area, where the mountains are still lower. Pharaoh mountain is conspicuously the highest of the gneissic peaks, and stands out as a landmark for miles. Its height is 2557 feet.

Though the mountains are not very high, they are rugged and often very steep. The greater part of the region is an untraveled wilderness, and some parts of it are very difficult of access. The abandonment of the iron mines, which were formerly of economic importance, has led to the desertion of villages, and the region abounds in houses which are falling in ruins. One can easily travel for days through unbroken woods without meeting with a house or even a trail. Lumbering and forest fires have done their work here as elsewhere in the Adirondacks, with the result that the thick second growth has made travel difficult and outlooks few.

The drainage is in part westward, emptying into the Schroon and hence ultimately into the Hudson, and in part eastward toward Lake Champlain. The divide between these two drainage systems lies along a general north and south line, the westward drainage comprising about two thirds of the quadrangle. The most important stream is the Schroon river, which crosses the northwestern corner of the quadrangle. Its present course is for the most part over drift, some interesting terraces being displayed on the sides of its valley. Its most important tributary is the Paradox valley, which crosses the quadrangle in a southwesterly direction, joining the Schroon near the central portion of the western edge of the quadrangle.

Plate 2

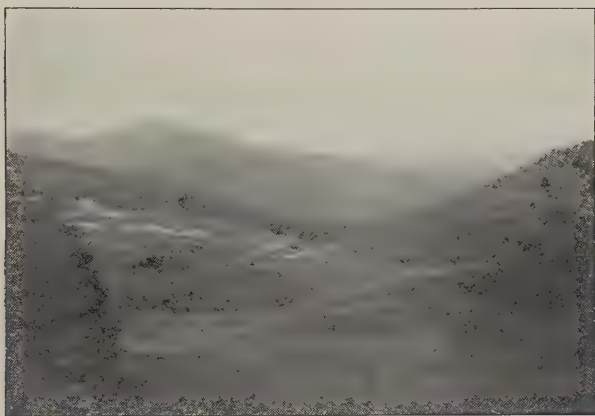


Fig. 1 Hammondville N. Y.

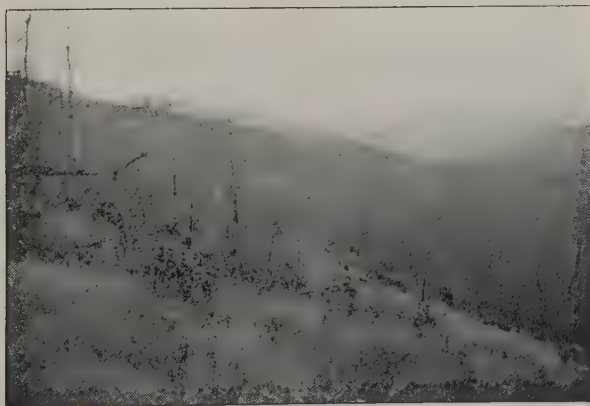


Fig. 2 Valley of Rock Pond brook. Gentle slopes and broad valleys characteristic of the gneissic area





The drainage is well-adjusted, the principal valleys being either upon the limestone or in the depressions occasioned by block faulting. The limestone valleys are usually wider and physiographically older than the faulted valleys. This contrast is shown in plate 1, figure 2, where Chilson lake in the foreground lies in a limestone valley, while the steep face of Knob mountain marks a fault cliff which extends northward about five miles.

Glacial agencies have interrupted the last erosion cycle, hence this valley at the foot of Knob mountain is not occupied by a single stream but by three small lakes and a considerable extent of swamp, outletting westward in its middle portion. The limestone valleys are also drift-filled, but their drainage is usually not so markedly disarranged as it is in the narrower faulted valleys. Plate 3, figure 1, illustrates the condition in the wider valleys.

## PART 2

### PHYSIOGRAPHY AND GLACIOLOGY

#### Cambric drainage lines

Certain main lines of drainage were established before the close of Cambrian time. These have been greatly modified by later adjustments—in addition to normal valley development, drowning, rejuvenation, faulting and glaciation entering into their history at various times—nevertheless the Cambrian drainage can be made out and is in some localities remarkably similar to the present.<sup>1</sup>

The Lower and Middle Cambrian strata are found in Vermont; only the Upper Cambrian in the Adirondacks. This fact indicates that the Cambrian sea advanced from the east, its progress being slow. It covered Vermont in Middle Cambrian time, but did not reach the Adirondacks until the Upper Cambrian.

Hence in Lower and Middle Cambrian time the Adirondack region was a land area, and was consequently being worn down by streams. Prof. Kemp has shown that these Cambrian streams were well adjusted to the structure, having placed their valleys on the limestone, and that these valleys had mature profiles and cross-sections.

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<sup>1</sup>J. F. Kemp. Physiography of the Eastern Adirondacks in the Cambrian and Ordovician Periods. Geol. Soc. Am. Bul. 8:408-12.

This region of mature topography was then drowned by the advancing Potsdam sea, the valleys first and later the highlands, being covered by aqueous deposits. The Cambrian strata are still horizontal or nearly so, hence their position in the valleys must be due to original deposition in depressions, and not to any kind of folding. In some instances their position may be due to faulting, but there was no evidence of such faulting in this region.

Potsdam outliers are found in three localities within the Paradox Lake quadrangle. One outlier is found on the extreme eastern edge of the map in the valley of Trout brook; a second near Chilson, outcrops in three localities, the intervening areas being drift-covered; the third two miles north of Sherman Corners.

The Trout brook outlier lies in a valley of mature cross-section, the present stream being rejuvenated and actively cutting. Were the Potsdam removed the valley would show the gentle slopes characteristic of a well established drainage line. The former extent of the Potsdam is indicated by many loose boulders south and west of the outlier.

The Chilson outliers are masked in drift, but they indicate the same thing—a mature Pre-Potsdam valley, drowned by the Potsdam sea.

The Sherman Corners outlier is now being cut by a vigorous post-glacial stream. The outline of the hills suggests that in this case also if Potsdam and glacial deposits were removed the valley would be mature.

The conclusion then seems inevitable that the main drainage lines were established in Pre-Potsdam time. The Trout brook valley, the Putnam creek valley and the valley two miles north of Sherman Corners are shown to be of Pre-Potsdam age by the outliers. By their similarity in stage of development the valleys of Chilson lake and of Paradox lake would appear to belong to the same period.

The Schroon valley is problematic in age and in origin. The largest valley on the quadrangle, it passes through the anorthosites with glacial terraces masking its sides. No limestone has been found in its basin, nor any Potsdam sandstone. The topography



Plate 3



Fig. 1 Chilson N. Y. Drift filled valley

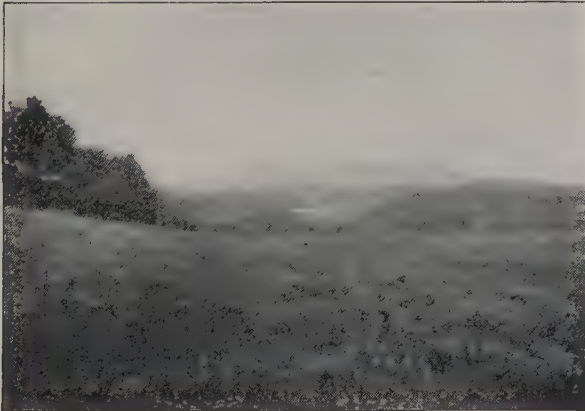


Fig. 2 Paradox. Limestone valley



suggests faulting, and its direction (s. 15 w.) suggests a later origin than that of the Cambrian valleys, whose direction is slightly north of east.

The invasion of the Potsdam sea from the east suggests that these Prepotdam rivers flowed toward the east. This is further borne out by the attitude of the rock beneath the drift, so far as it is known, and by soundings in the lakes. In Goose pond, Crane pond, Pyramid lake and Chilson lake soundings showed a slightly greater depth of the rock bottom in the eastern than in the western ends. An uplift of 25 feet in the western part of the quadrangle would reverse the drainage of several important streams. The Chilson lake valley, after such an uplift, would drain eastward into Penfield pond; Goose pond would drain into Crane pond and Crane pond eastward through Rock pond to Putnam creek; Black brook would pass eastward until diverted by the Knob mountain fault. After a reconstruction of the country, and after removing all drift and replacing all faults, this easterly direction of drainage becomes universal. If the faulted face of Treadway mountain were removed Pharaoh lake would drain through a wide and now dry valley into Putnam pond.

The conclusion is that the drainage was established when Cambrian time opened; that the general direction of drainage was eastward, usually northeast, occasionally southeast; that the streams at this time were adjusted to the limestone, and that the region was mature.

The alternative hypothesis, that the region was a peneplain in Cambrian time and the outliers dropped by faulting, seems untenable in the light of these various lines of evidence. There is no evidence of such faults, but every indication, short of absolute proof, that the valleys containing the outliers were normal erosion valleys established on the limestone.

Of the events of later Palaeozoic time there is little evidence within this quadrangle. Abundant fragments of Calciferous and of Trenton rocks suggest that the region was entirely submerged. An outlier of the Calciferous is found at Schroon lake, but none within the limits of the Paradox Lake quadrangle.



### Penепlains<sup>1</sup>

The even sky line of some of the mountains [pl. 4] suggests an uplifted peneplain. It is best displayed on Treadway mountain, but may also be seen on Springhill, Trumbull and several small unnamed mountains. Wherever found this flat rises slightly toward the northwest. Apparently this peneplain antedates the last period of faulting, since the eastward slopes of the fault blocks are invariably flat [pl. 4 and 5]. Since the rocks are igneous or metamorphic it is impossible to correlate beds or to restore the prefaulted surface with exactness. The fact that when developed on sedimentary gneiss these flat surfaces often cut across the bedding [pl. 4, fig. 2] is sufficient evidence of their origin from some process of down cutting. But whether one peneplain or more is represented is impossible to say until some estimate of the amount of faulting can be made. These flats are developed alike on undoubted igneous rock (Owl Pate, Bald Pate, Moose mountain) and on gneiss, possibly of sedimentary origin (Bear mountain, Skiff mountain, Knob mountain).

A second temporary base level is represented by the present valley floors. Like the older level this one is higher towards the northwest, but this second level follows the formation of the great faults.

### Summary of the preglacial erosion history

In Prepotdam time eastward flowing rivers were established on the limestone; these rivers were drowned by the Potsdam sea, and the whole country covered by the Lower Siluric. From the Siluric

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<sup>1</sup>A peneplain, i. e., almost a plain, can best be defined in terms of a "base-level" or "graded slope." The last two terms are both used by different authorities to describe that condition of a land surface which is reached when, after erosion by streams, the slope is just sufficient to carry off the water without permitting either additional erosion or transportation. It is a plain as near sea level as river erosion can bring it, and it is a limiting condition which is approximated even if never reached. At a stage shortly preceding base-level, the surface would be a peneplain. A peneplain then is a nearly plane surface at sea level, produced by the erosion of streams. Should such a peneplain then be elevated and subjected to erosion again, evidence of it would remain in that the tops of the hills would be flat. These flat hilltops stand at about the same elevation, and the rock forming such flat topped hills may be of any kind or of any structure.

Plate 4

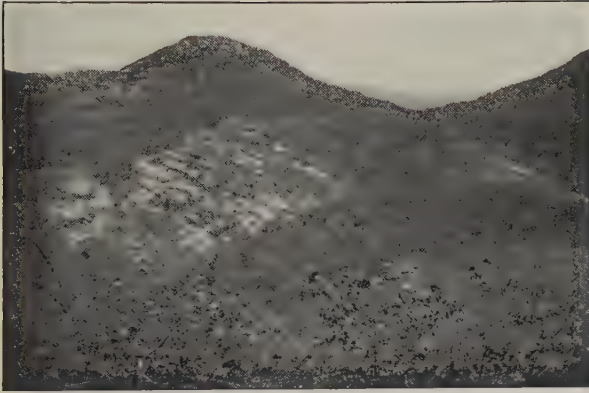


Fig. 1 Mountain 1 mile southeast of Crane pond. Peneplain cut on sedimentary gneiss



Fig. 2 Mt Treadway from Pharaoh lake. Peneplain cut across beds of dipping sedimentary gneiss



until the Pleistocene the region was a land area and of the events of this immense period of time there is very little record. Whatever the details may have been, erosion was going on, and the covering of early Palaeozoic rocks was being removed. A peneplain was finally produced.<sup>1</sup>

An uplift followed which was greatest in the northwest, and which was accompanied by block faulting. A new cycle of erosion began, continuing to remove the Palaeozoics from the Prepotdam valleys, and also developing new lines of drainage adjusted to the faults. Another uplift followed, which was also greatest in the northwest. The next erosion cycle was interrupted by the glacial period. I believe that these conclusions are in a general way in accord with Dr Cushing's observations in the north.<sup>2</sup>

#### **Age of lower base-level**

The age of this lower level in the Adirondacks can be fixed within probable limits. The valley floor on which the drift was deposited belongs to it and the streams had just begun to incise their channels. Since therefore they had just begun to lower their channels before the glacial period, the date of rejuvenation must have been late Pliocene. If the rejuvenation of them closed the Pliocene, the cutting of the lower level must have taken place in the earlier Pliocene and Miocene.

#### **Glacial deposits and drainage modifications**

When the ice entered the region it encountered a drainage long established and well-adjusted, but physiographically young in that the region had recently been rejuvenated. After its withdrawal it left the valleys completely drift-filled and the courses of the rapidly cutting streams determined by the slope of the drift.

The glacial deposits in this area are divisible into two groups; those of unassorted material, consisting of heterogeneous mixtures of all sizes of constituents from large boulders to fine sand, with occasional admixture of clay; and those composed of fine gravel,

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<sup>1</sup>Analogy with other regions would suggest Cretaceous age for this first base level and Tertiary for the second, but no evidence of the age was found within the region itself.

<sup>2</sup>Geology of Franklin County. N. Y. State Geologist 18th An. Rept 1899.



sand, or silt, with a stratified structure. The first class comprises what is generally known as till, and as boulder clay, and is generally sprinkled over the surface. The stratified deposits overlie the thin till covering, but the two were probably laid down contemporaneously in different localities, some till being formed at the margin of the ice at the same time that aqueous deposits were gathering farther from its edge. No true moraines were found within the limits of this quadrangle. Ridges of rounded glacial hills occur in several localities, but they all proved to be of fine stratified material.

The region lay so far within the ice sheet that any deposits formed in its advance would subsequently have been removed, and the same would be true of any earlier gravels which may once have been there. The surviving deposits belong to the time of retreat and melting of the ice, at the close of its last invasion.

The erosion history and glacial phenomena of the Adirondacks as a whole were summarized by the writer in a recent paper.<sup>1</sup> In this paper it was shown that the general direction of ice movement was toward the southwest; that the motion was vigorous among the outlying lower hills, but that among the higher mountains the ice was stagnant in the bottoms of the deep valleys, while at the time of the maximum extension of the ice sheet it passed over the tops of these filled valleys smoothing the mountain summits. It was further shown that the glacial deposits belong in general to the time of retreat and melting of the ice, being largely of stratified material.

The Paradox Lake quadrangle lies on the border between the regions exhibiting the two types of glaciation. Its northwestern part lies in the region of high peaks and deep valleys, where there is little sign of glaciation except in the smoothed tops of the mountains. The more southerly and easterly parts of the quadrangle were in the region of the southwesterly moving ice current, hence smoothed rock faces and roches moutonnées are common, as are also glacial deposits.

**Crown Point.** In the northeastern corner of the quadrangle, 900 feet above sea, in the valley about two miles south of Towner pond

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<sup>1</sup> On Glacial Phenomena in the Adirondacks, Jour. Geol. v.10 April-May, 1901.

Plate 5

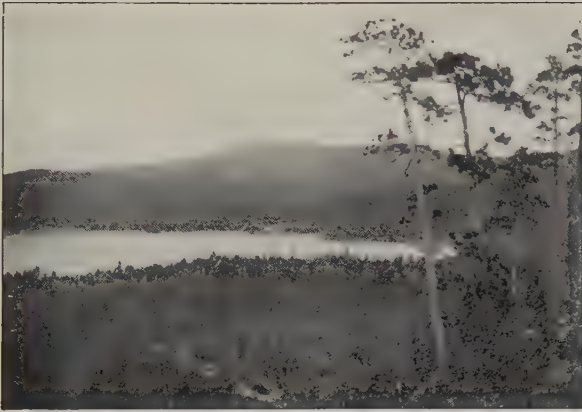


Fig. 1 Mt Treadway from Pharaoh lake. Peneplain cut on sedimentary gneiss

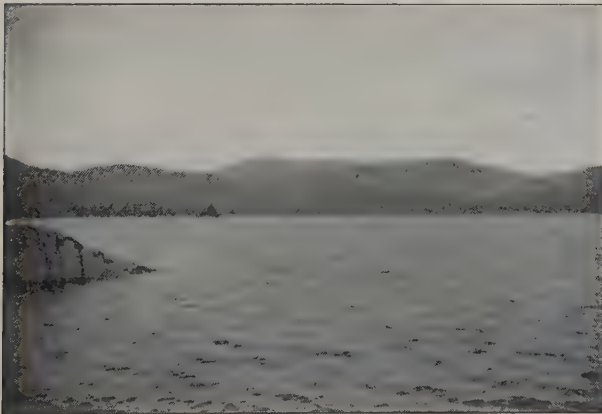


Fig. 2 Mt Treadway from Pharaoh lake. Peneplain cut on sedimentary gneiss



and the same distance north of Sherman Corners, is the flat bed of what was probably a small glacial lake. This lake was of short duration, not lasting long enough for the development of shore features. It was formed by the damming of a preglacial channel by the retreating ice, and its waters were supplied in part from the melting edge of the ice and in part from the eastward flowing drainage of the valley. At the margin of the ice, stratified drift hills were deposited which blocked the valley on the east after the ice had retreated. The water speedily found a new outlet farther south and the lake was drained.

At present the stream meanders over the old lake flat, having cut its channel and built a flood plain below the lake level. Its preglacial outlet is blocked by the ridge of stratified hills, and where it meets them the stream turns southward. The road to Crown Point now runs through the preglacial valley, and a branch road to the north has cut through one of the stratified hills, whose material is now being removed for gravel. In this exposure beds of coarseness varying from very fine silt to pebbles of about two inches are seen, with some cross-bedding. Farther east beyond the line of these hills typical boulder clay is found.

The stream has cut a postglacial channel around the hills that blocked its old valley, and after rounding them to the south it turns northward again, cascading over ledges of Potsdam sandstone and cutting a little canyon. The drift dam was formed at the top of a steep hill, which leads downward to Lake Champlain, and the stream descends this hill through a postglacial valley. After reaching the lower level it turns northward and reenters its preglacial valley. At the foot of the hill is another small flat which may represent another temporary lake, but its complete interpretation needs investigation beyond the limits of this quadrangle. Stratified deposits are also present along the valley leading northward from this glacial lake to Towner pond, these deposits being extensively eroded postglacially. Like the hills of the dam just described, these deposits show great variation in size of material and often cross-bedding. They were evidently formed by swift waters, and probably represent glacial outwash.



Towner pond is held up by an artificial dam sixteen feet high, the original pond being a small solution basin in the limestone at the eastern end of the present pond. The artificial dam has resulted in drowning several tributary valleys. At its principal inlet is a fall and a small natural bridge over crystalline limestone [pl. 6]. This fall is postglacial. East of the pond, surface drift is abundant, some true till being present [pl. 7]. No well data are available, but the topography suggests an eastward preglacial outlet.

The valley leading westward towards Overshot pond is filled with much drift, mainly sand and gravel. Several ridges of terminal morainic aspect are present, running in a general east and west direction. There were no cuts into these ridges. To the west, at the end of the trail, the valley broadens out in a manner abnormal for the upstream part of a small creek. A sand flat fills the bottom of this basin. No lake shore features were found about this flat; it probably represents a lake whose life was of short duration.

**Ticonderoga.** Three miles north of Chilson is a line of kames,<sup>1</sup> extending southwest for a mile and crossing the angle of the main road where it turns westward. A cut across one of these shows the material to be sand, the bedding highly inclined. Emmons in his report refers to the ridge. Immediately south of this ridge lies a swamp, its flat extending about a mile in each direction, inclosed on three sides by gneissic hills, on the fourth by the ridge of kames. Its outlet cuts across the kame belt and cascades westward through a postglacial valley into Putnam creek. The probable history of the drainage in this region is illustrated in the diagrams [fig. 1-3]. Figure 1 represents the normal river valley which would result were all Potsdam deposits, faults and glacial drift removed. Figure 2 represents the same region after the Potsdam deposits had filled the valley and the work of reexcavating had only partly followed the old channels; the basins of Putnam pond, North pond, Rock pond and Bear pond had been added by faulting. Figure 3 represents the

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<sup>1</sup>A kame is a hill or short ridge of stratified glacial drift. Kames were formed at the edge of the ice, of material which had been transported by the ice, deposited by water issuing from the ice.

Plate 6



Inlet of Towner pond. Small natural bridge in limestone



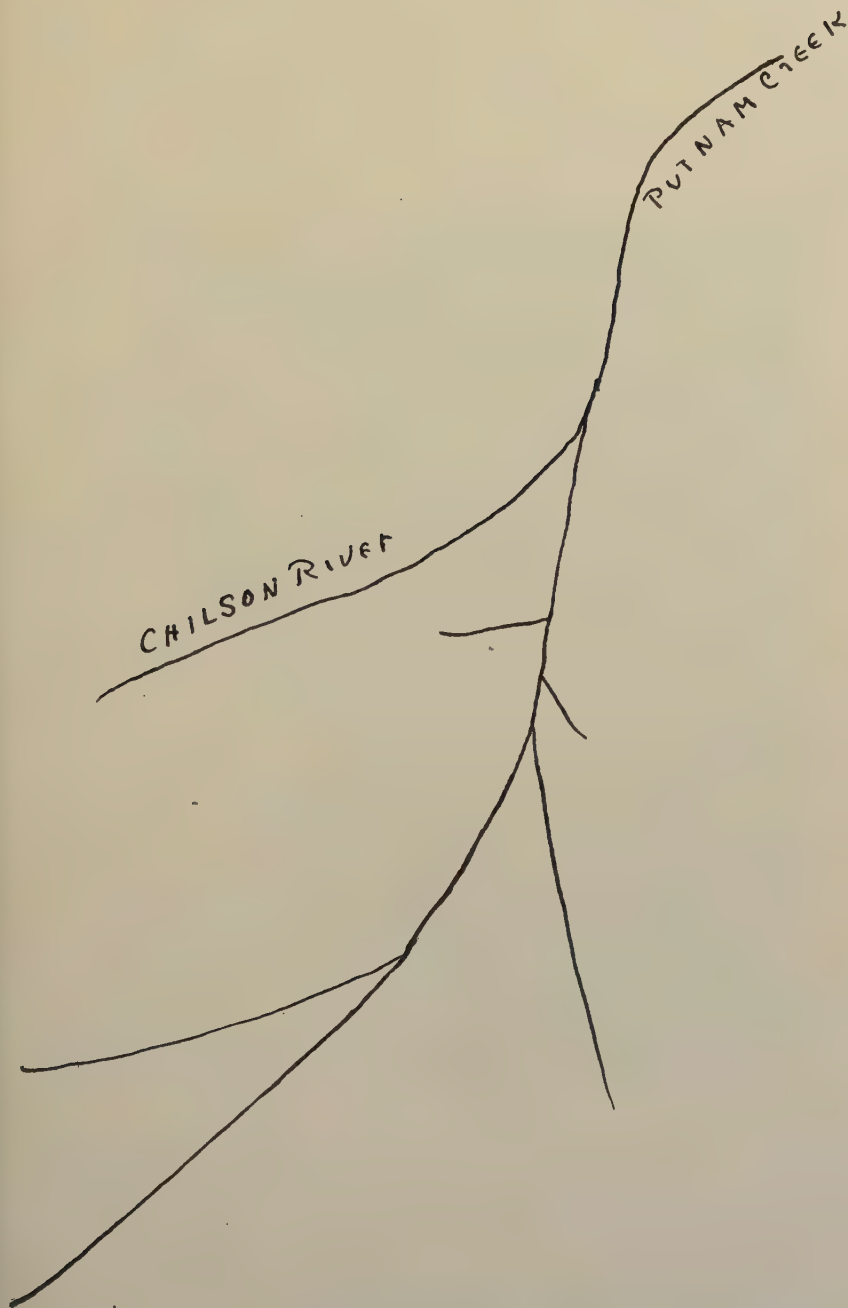


Fig. 1 Hypothetical Prepotslam drainage



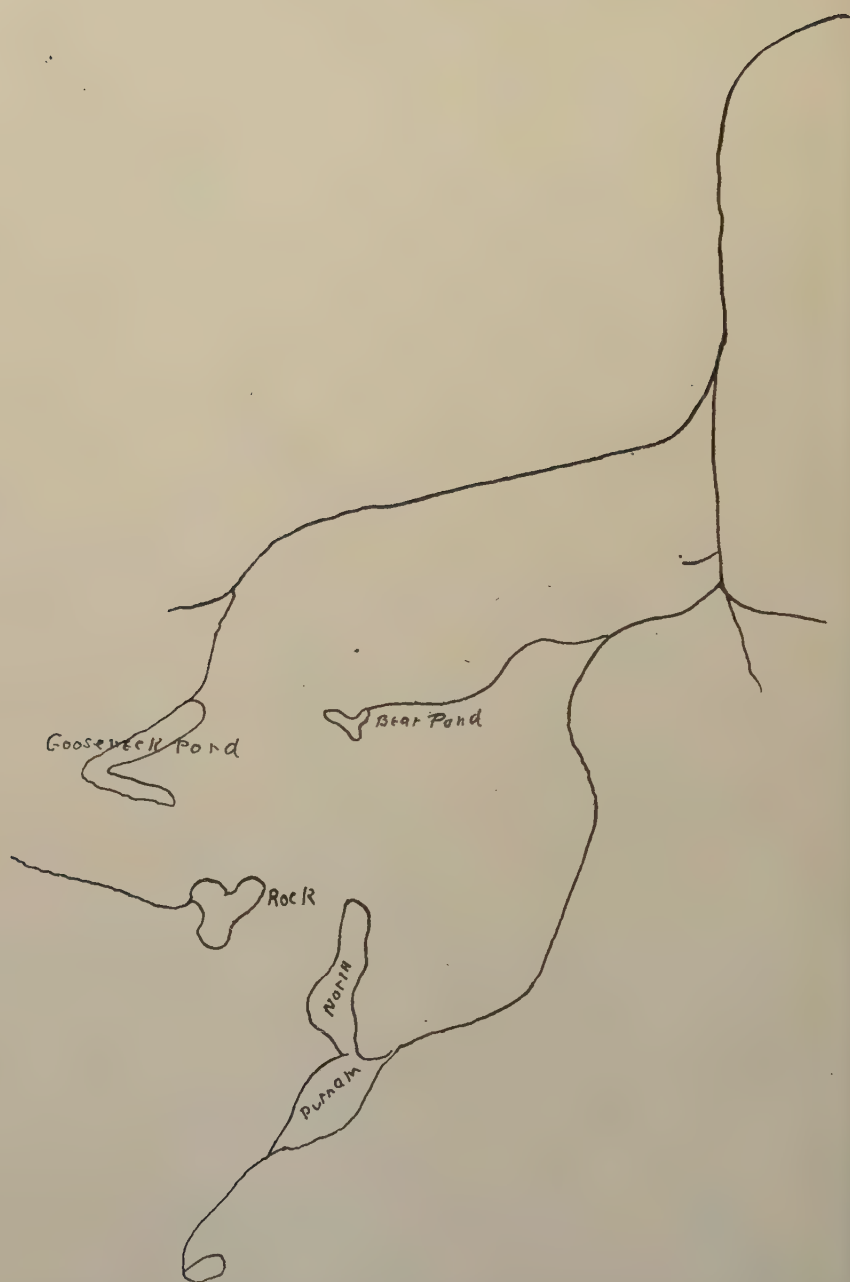


Fig. 2 Hypothetical drainage at a time later than the Siluric; later than the faulting; before the ice invasion

Plate 7



Till; south of Towner pond



present drainage, the additional lakes being caused by drift-filling or postglacial water-laid deposits, with the exception of Penfield pond, which is partly artificial. The swamp in the southwest corner

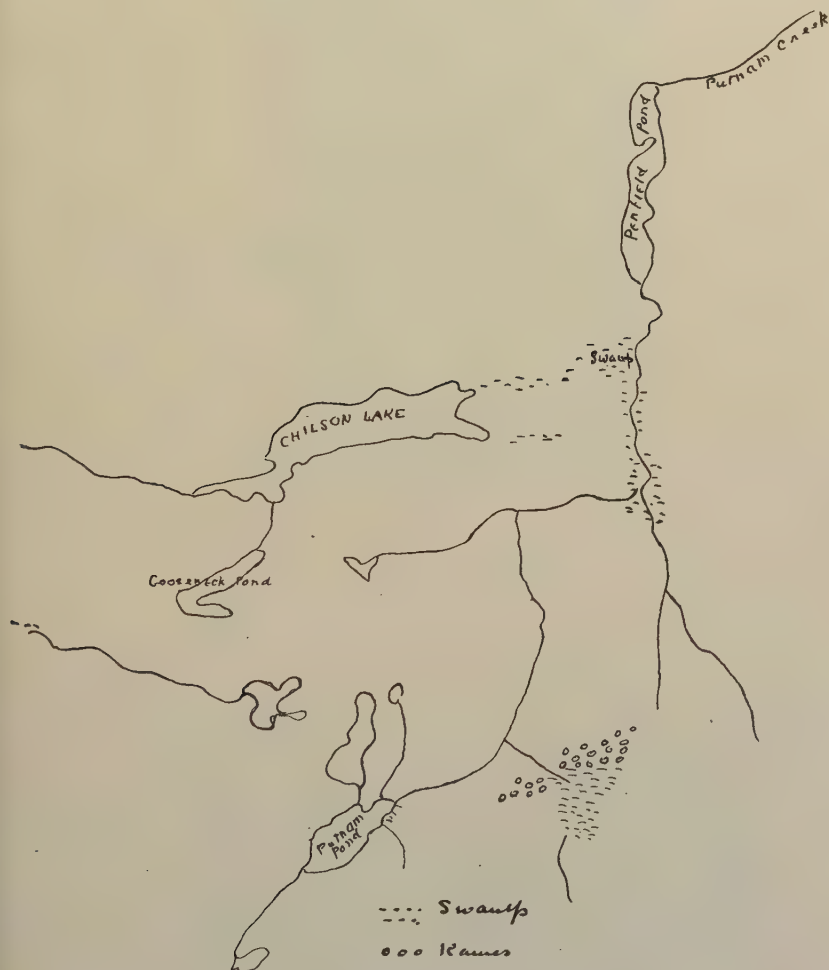


Fig. 3 Present drainage

is the one above referred to and probably represents a lake of Champlain age.

**Hague.** The brook in the southeastern corner of the quadrangle flows through a broad preglacial valley, now filled with rolling hills

of stratified drift. The upper course of the present stream is superimposed over this drift-covering and wanders considerably, having developed a broad flood plain in its upper course. No evidence was found of a glacial lake in this locality, the evidence pointing towards the filling of the valley by drift deposited by the escaping floods from the melting ice. Rock first appears at the bridge (one inch from the eastern end of the map) and downstream from this point the course alternates between quiet reaches, where the stream flows over drift or along the strike of the gneiss, and little cascades and rapids, where it flows southward down the dip. At the largest fall the Hague gristmill is situated, the fall in this case resulting partly from a soft, easily eroded shear-zone in the gneiss at the base of the present fall. Below this fall the stream bed is full of loose material, in part at least of postglacial origin and resulting from the cutting back near the fall. A similar fall occurs at the corner of the map.

Potholes are found at these falls, and at the one at the gristmill a little lake has been formed part way down the fall from the wearing away of a soft layer [pl. 8, fig. 1].

Trout brook also flows through an old drift-filled valley, slowly meandering in its upper course, and alternating between quiet reaches and rapids, according to whether its drift cover is or is not cut through. The rock here being massive, no such changes can be seen as in the southern brook. Close to the edge of the map Trout brook reaches the Potsdam sandstone and turns abruptly northward. It leaves an open valley only three fourths of a mile in length which leads east straight to Lake George, and turns abruptly northeast, emptying into Lake Champlain six miles away. Its lower course is on the Ticonderoga quadrangle.

This northeastward bearing valley is a very old one. Small exposures of limestone indicate that it was originally excavated upon a limestone fold. The Potsdam sandstone lies undisturbed in three localities on its lower course, suggesting that the valley existed in Cambrian time and that it was drowned by the Potsdam sea. In Champlain time the valley was occupied by the water, probably of an arm of Lake Hudson-Champlain. Since the shrinkage of this



Plate 8



Fig. 1 Hague grist mill. Cascade down the dip of quartzite

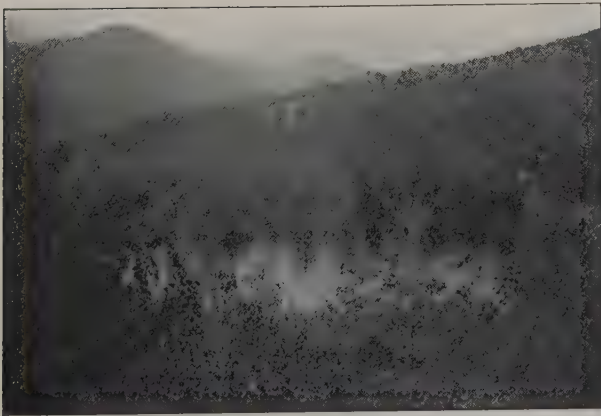


Fig. 2 Pond in cirque, Skiff mountain



glacial lake, the lower Trout brook has reestablished itself in this old valley and has beheaded upper Trout brook whose former course was eastward, over hard gneisses.

**Horicon and Schroon.** Pharaoh lake and Wolf and Whortleberry ponds lie in rock basins caused by faulting. The outlets of Pharaoh lake and of Whortleberry pond join, and together are combined with Desolate brook. The junction of these three streams takes place in a broad valley filled with stratified drift.

Desolate brook is now a swamp or "vly," its still waters having been filled with sphagnum and other vegetation. The trail mapped is now impassable owing to the increasing swampy conditions.

At the northern end of Schroon lake is a wide flat extending northward for about three miles. This flat appears to be a glacial delta. At present the Schroon river meanders over its surface, and the greater portion of the flat is swampy.

**Schroon and North Hudson.** The Schroon river in its southwesterly course extends for about five miles within the limits of the quadrangle. On its banks are well-developed terraces.

In the course of these five miles the river descends 50 feet. Its most conspicuous terrace drops from 960 feet in the north to 930 in the south—30 foot fall in the same distance in which the present river falls 50 feet.

The surface of this terrace is slightly uneven and suggests an origin as a kame terrace, while the ice still stood in the valley. The front of this terrace has been extensively eroded, in part by the Schroon river, which has built a lower terrace of flood plain origin, and in so doing has worn back the face of the older one; in part by recent gullyng. Gullies once started grow with astonishing rapidity, houses and the highways being frequently undermined. The material of this terrace is sand.

A higher terrace is to be distinguished at a few localities. This higher terrace is partly built, partly cut. It occurs 35 feet above the main terrace. Through the Schroon valley sand dunes abound, the material loosened along the gullies being blown by the wind and deposited on either of the two lower levels.

The main terrace of the Schroon extends up its tributary, Black brook.

**Cirques<sup>1</sup> and grooves.** Glacial cirques are found in at least three instances within this region. One of these is on the southern slope of Cat mountain, near the northern boundary. This cirque contains a small pond which is not on the map. A second is on the southern slope of Skiff mountain [pl. 8, fig. 2] and also contains a pond. The third is on the southwestern slope of Mount Steven; this one does not contain a lake.

On the northern shore of Paradox lake is a large glacial groove, displaying a smoothly polished surface [pl. 9, fig. 1 and 2].

Striae are rare. Those found have already been recorded.

Boulders are common, some of considerable size. These boulders are of all kinds of Adirondack rocks, Potsdam sandstone being very common.

### PART 3

#### General geology

The crystalline rocks of the Adirondacks are part of the great series forming the Laurentides of Canada. It has never been doubted that these crystalline rocks are of Prepotdam age.

The Potsdam sandstone lies almost undisturbed upon their eroded surfaces, and in Prepotdam time the Precambrian sediments had been tremendously folded and faulted and intruded at great depths by at least one series of plutonics. They had then been uplifted and worn down many thousands of feet until only the cores remained, and until their surfaces had attained a topography of only moderate relief. This surface had then sunk beneath the advancing Potsdam sea.

**Distribution and character of formations.** The crystalline complex consists in part of sedimentary rocks, lithologically identical with the Grenville series of Canada; in part of intrusives, which resemble the Norian series of Canada, and in part of other intrusives being of different character.

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<sup>1</sup>A cirque is an amphitheater with precipitous or very steep sides which is excavated by a glacier at its upper portion. The ice cracks off and carries away the rock from the mountain until by eating backward it leaves these precipitous walls surrounding the valley on all sides except its outlet. Cirques often contain small lakes.

Plate 9



Fig. 1 Glacial groove. North shore of Paradox lake



Fig. 2 Glacial groove. North shore of Paradox lake





**Sediments of the Grenville series.** Probably the oldest rocks on the quadrangle are metamorphosed sediments. Probably also only one series of Precambrian sediments is present. Six types of sedimentary rocks are recognized: hornblende gneiss, limestone, mica schist, silimanite gneiss, graphitic quartzite, shaly quartzite.

**Hornblende gneiss.**<sup>1</sup> Typically this rock is a very quartzose hornblende gneiss. It is of gray color. Its sedimentary origin is indicated by its large quartz content; by certain persistent streaks of brookite schist which appear to represent changes in composition which could only be explained by changes in sedimentation from sandy conditions to shaly ones; and by its vertical changes in mineral composition [see pl. 4, fig. 1]. The gneiss extends in a horseshoe-shaped belt through the central, southern and western portions of the quadrangle, containing within its area some of the most important mountains, namely, Treadway, Putnam, Stevens, Third Brother, Park and others. This gneiss is so excessively crushed, and also so much altered by syenites, pegmatites and quartz veins, that no structural features could be made out.

**Limestone.** Closely associated with the gneiss occurs crystalline limestone. It is a completely recrystallized rock, which presents such remarkable metamorphic features that it was first supposed by Emmons to be of igneous origin. Little trace of bedding is to be found. While at times almost pure, it often contains metamorphic minerals, such as graphite, apatite, pyroxene, amphibole, phlogopite, biotite, scapolite, garnet, titanite, pyrrhotite and tourmaline. Most of these minerals are clearly the result of regional metamorphism acting upon impure limestone, but some of them, notably tourmaline, titanite and scapolite, are the result of contact metamorphism. In Moriah, just north of the region covered by this map, the limestones are found charged with serpentine, forming the rock known as ophicalcite.

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<sup>1</sup>Gneiss is a laminated metamorphic rock having the mineral composition of a granite, but not necessarily in the same proportions. Varieties are indicated by prefixing the name of the most important silicate, thus hornblende gneiss is a rock containing quartz, feldspar and hornblende.

These limestones undoubtedly represent calcareous sediments charged with magnesia, iron, silica and alumina, the latter elements forming the various silicates during metamorphism. Graphite is almost universally present.

The intense metamorphic changes which result in great contortion or complete crushing when applied to sandstone result in flowing and recrystallization when applied to limestone. The crystalline limestones of the Adirondacks have lost their original features and with recrystallization have developed polysynthetic twinning, parallel  $\frac{1}{2}$  R. The limestone is thoroughly crystalline throughout its extent, and its condition can not be explained as a result of contact metamorphism from the associated intrusions. Contact effects have been described by various writers in various Adirondack localities, but on the Paradox Lake quadrangle the contact metamorphism resulted in changes in the intruded rock.

The limestone is found in the wider valleys in long belts and in a few isolated patches among the hills. One long strip of it lies along the Paradox valley, while another forms the shores of Penfield pond. Gneiss and schist are often interbedded with it, and the dip can sometimes be discovered from these layers. The limestone itself is so completely recrystallized that as a rule no bedding can be made out. The only locality where a dip and strike could be determined in the pure limestone was in a little canyon on the south side of Paradox lake, where there was a little cave in the side of the cliff. Similar caves are common, and so are little natural bridges and other forms resulting from solution.

In the northwestern part of the Penfield pond limestone belt are a series of little hills of limestone interbedded with gneiss. Near Dudley pond the outcrop of alternating gneiss and limestone is repeated by a fault, the beds here dipping gently east. Farther south the limestone becomes purer; its associated gneiss stands out as several good sized hills, and no interbedding is seen.

**Mica schist.**<sup>1</sup> Typically a biotite schist, containing occasionally a little hornblende, and sometimes grading into a gneiss this rock

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<sup>1</sup>Schists differ from gneisses in that they have finer laminations. They often have the same mineral composition as the gneisses, but sometimes are more basic. They are classified according to the principal dark silicate present.

Plate 10



Trap dike in gneiss, north shore of Pharaoh lake. The trap weathers more readily than the gneiss





invariably accompanies the sedimentary gneiss and the limestone. It occurs in bands interbedded with limestone or gneiss, the bands varying from a few inches to some feet in thickness. They are never of sufficient size to be mapped separately.

The association of limestone with schist and with banded gneiss has frequently been noted in the Adirondacks. In the Paradox Lake quadrangle the rocks were so involved and exposures so limited that no stratigraphy could be made out. The relations, however, were shown in a locality about forty miles to the west, in a gorge cut by the Hudson river. Between the points where the Indian and the Boreas rivers join the Hudson there are about eight miles of rapids, frequently bounded by cliffs. Here a section is displayed, notably in the cliffs forming the "Blue Ledge" and in the cliffs above "Carter's Riff." It is evident that gneiss, schist and limestone constitute a single conformable series, the gneiss being beneath, the schist forming bands interstratified with both gneiss and limestone. It is further evident that the contact between gneiss and limestone is not a sharp one. There is an alternation of thin beds of gneiss and of limestone, passing upwards into pure limestone.

The evidence from the gorge of the Hudson can certainly be applied to the same rocks when too much crushed to show structural relations. In the Paradox Lake quadrangle both faulting and crushing have been excessive, but it is safe to conclude that here also the gneiss is beneath, the limestone above, with more or less intermingling along the contact.

**Sillimanite gneiss.** The outcrop of this rock at the mine at Graphite has already been described by Professor Kemp.<sup>1</sup>

Both the foot and the hanging walls of the mine consist of it. The garnet and graphite are the only minerals to be distinguished in the hand specimen. The graphite of the mine is developed in a quartzose layer along which there has been shearing in the direction of the bedding.

Another occurrence of sillimanite gneiss is on Bear Pond mountain, but it differs slightly from that at Graphite. Garnets made

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<sup>1</sup>Geology of Washington, Warren and Essex Counties N. Y. State Geol. 17th An. Rept 1899. p.539.

up a large proportion of the rock at Graphite, while on Bear Pond mountain they are entirely absent. Whereas the Graphite occurrence is massive, the Bear Pond mountain variety consists of thin layers interbedded with sandy quartzite. There has been much shearing and crumpling, and the whole series is impregnated with iron oxids. The bedded nature of this sillimanite gneiss is certain.

At Graphite, limestone has been found in a prospect boring, beneath the sillimanite gneiss. At Bear Pond mountain the sillimanite gneiss overlies the hornblende gneiss, no limestone being present. These relations suggest the possibility of an unconformity between the sillimanite gneiss and the limestone series, although the limestone is so patchy in its general distribution as to prevent too confident drawing of conclusions.

The graphitic sandstone occurs in a small area about North pond. It is a gray variety, weathering red, dipping steeply west, and containing abundant flakes of graphite and of mica. On the north-east bay of Rock pond a small mine has been opened. The graphite occurs along a fault line, associated with iron pyrites. Slickensides are abundant in the opening. The country rock is the above described quartzose gneiss, of probably sedimentary origin. The biotite schist, commonly interbedded with the limestone, appears near the mine. The sillimanite gneiss is present on the neighboring mountain. The strike of the graphitic sandstone is n. 5 e., its dip 70 w.

The sandstone is similar to the layer bearing the graphite at the mine of Graphite. The chief difference is that whereas at the Graphite exposure flakes of graphite form the principal constituent of the rock and the only scaly constituent, at North pond mica is also present. The North pond rock is hence less valuable economically, since it not only contains a smaller percentage of graphite, but the process of concentration would be complicated by the presence of two scaly minerals. Both rocks contain much accessory pyrité, and weather yellow or red.

Geologically the two rocks probably represent the same formation, and both are intimately related to the sillimanite gneiss. The silli-

Plate 11



Penfield limestone belt with interbedded schist



manite gneiss represents shale, and the graphitic rock the sandstone of the same series.

**Shaly quartzite.** Overlying the garnet-sillimanite gneiss of Graphite is a quartzite, impure and feldspathic, in some localities sheared into a schist. It occurs also in the bed of the brook at the extreme southeastern corner of the quadrangle. Several fault lines can be seen along the brook, the most notable one being at the Hague gristmill [*see* pl. 8, fig. 1].

The exposure at the graphite mine in the village of Graphite is separated from an eastern one at the Lakeside mine, Hague, by a hill of syenitic gneiss and by drift in the valley. The uniform strike for both localities is n. 65 e. and the dip of variable amount, toward the southeast. The eastern exposure would hence appear to be the upper one, but the frequency of faults makes its position uncertain. Some layers at the extreme eastern edge of the map are conglomeratic.

**Summary of stratigraphic relations.** The oldest rock is the hornblende gneiss; conformably above this is limestone; interbedded with both is the biotite schist. Above these, possibly with an unconformity, is the sillimanite gneiss; interbedded with it as a local variation is shaly quartzite; above these, graphitic sandstone.

**Intrusives.** It has long been recognized that the core of the Adirondacks consisted of a rock of the gabbro family which has been named anorthosite. It has also been long recognized that gabbros of later age than the anorthosite were widespread. Of late years another type of intrusive has been recognized by Dr Smyth on the west and by Prof. Cushing on the north, and has since been found throughout the region, the most common phase of this rock being a syenitic one. All of the above types occur in the Paradox Lake quadrangle. A fourth variety which has not yet been recognized as a distinct type, although phases of it have been described, is also present in large amount in this quadrangle. This will be here called the Pharaoh type from the mountain where it is best exhibited. It presents the general mineralogy of a granite, but appears to be a different rock and older than the granite found in the



northern and western Adirondacks. The anorthosite, syenite and granite are all characterized by sudden and very great variations in the distribution of the ferro-magnesian constituents. These constituents may be gathered together, giving the rock locally the appearance of a gabbro, or they may be wanting altogether, giving in the case of the anorthosite a pure plagioclase rock, in the case of the syenite a plagioclase, orthoclase and microperthite rock, and in the case of the granite an orthoclase, quartz, microperthite rock. The basic varieties are the confusing ones, for with increasing ferro-magnesian constituents the three types approach each other very closely. Later than all three is the typical gabbro. All are plutonic and younger than the sediments.

**Granite.** Granitic rocks form a considerable area in the southwest, including Pharaoh mountain and several unnamed peaks of some importance. The rock, usually pink in color, is a hornblende granite, but sometimes contains considerable quantities of biotite. It is frequently gneissic, the granite gneiss sometimes being hard to distinguish from the syenite gneiss and the gabbro-gneiss. The igneous gneisses may readily be separated from the sedimentary ones by their massive character and by their uniform appearance over wide areas.

That this granite is later than and intruded into the limestone series is indicated by numerous pegmatite dikes and bosses. In passing from Mount Pharaoh to Mount Treadway one traverses first coarse granite dikes, then pegmatites, and finally to the east of Treadway, quartz veins. This is strongly suggestive of the natural and normal relations which so often occur around intrusives.

**Syenite.** Rocks of this type are proving to be one of the commonest of Adirondack intrusives. The type was first described by Dr Smyth, and has since been found in many localities, proving to be an extensive component of the gneissic areas.<sup>1</sup>

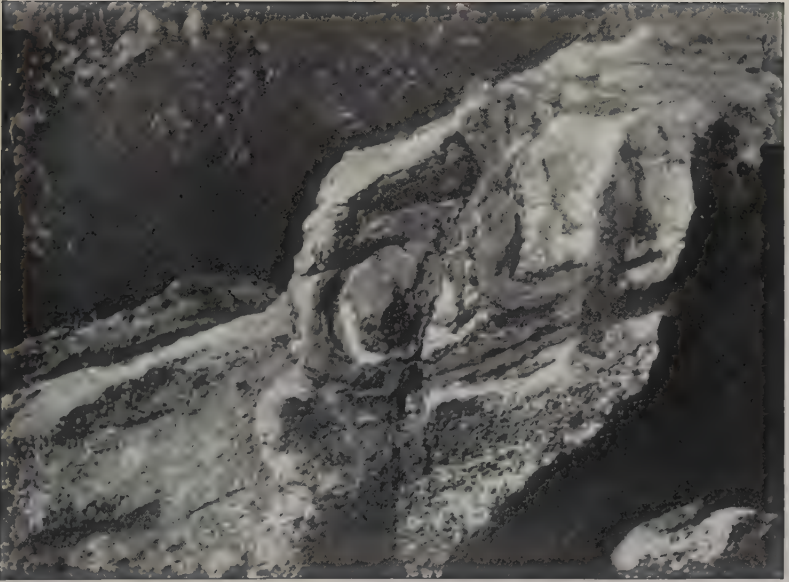
The occurrence in the Paradox Lake quadrangle is in all respects similar to those already described.

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<sup>1</sup> Smyth, C. H. jr. Geol. Soc. Amer. Bul. 6:271-274; N. Y. State Geol. 17th An. Rept 1899. p.471-486.

Cushing, H. P. Geol. Soc. Amer. Bul. 10:177-192; N. Y. State Geol. 18th An. Rept 1899. p.105-109.

Plate 12



Towner pond. Recrystallization of limestone, accompanying twisting of interbedded schist



The typical appearance of the rock is massive, with a dark green color. It has a tendency to weather far below the surface, and when weathered the color changes to yellow or brown. It is often of gneissic structure, and when this is the case the color often becomes a dark gray.

As shown on the map, the syenite occurs in several isolated areas, the largest being in the northeast. Another smaller area is on the eastern shore of Schroon lake, where syenite and granite grade into each other without perceptible contact.

In the southeastern syenite area, on the mountain 1913 feet high, locally called Trumbull (not the Trumbull of the map) there occurs an interesting exposure of sedimentary gneiss in the midst of syenite. It forms a small eastern spur of the mountain and is too large to be a fragment torn off by the intrusion. It must represent an area of the sediment yet in place, at the top of the intrusion and surrounded by it.

**Anorthosite.** As shown on the map, there is a large area of anorthosite in the northwestern part of the quadrangle. This area marks the southern and eastern extension of the intrusion which forms the main mass of the highest mountains in the Marcy region. The topography of this section is more rugged, with higher mountains and deeper valleys than the surrounding areas of gneiss, this difference being probably not due to greater hardness in the rock but to two dome-shaped uplifts.

The name "anorthosite" has been often erroneously criticized because of a supposed mistake in the first determination of the feldspar. It was not named from anorthite, but from "anorthose," which was an early French name for all triclinic feldspars as opposed to "orthose," for all monoclinic ones. Hence "anorthosite" means literally "plagioclase rock."

The anorthosite is typically a coarse grained rock of bluish or greenish color containing large iridescent crystals of labradorite. The dark silicates are usually gathered together in bunches, the prevailing rock consisting of feldspar only. About the border of the anorthosite area the rock is gneissic. As already mentioned, the

anorthosite area occupies a central position in the Adirondacks. The area within the Paradox Lake quadrangle comprises a segment of the outer portion of the intrusion, and in it a series of metamorphic changes are evident. These will be described in part 4, on petrography.

The anorthosite forms the highest and most rugged mountains in the quadrangle.

**Gabbro.** In a few small patches gabbro rocks occur—true gabbro, norite, and hornblende gabbro (meta-gabbro). The most important exposure is on Peaked hill.

The gabbro is typically a medium grained rock, of greenish black color. The dark color serves to separate the rock from the anorthosite and syenite.

Several dikes of the gabbro are found. On the southern shore of Pharaoh lake a gabbro dike cuts gneiss; on Bull Rock mountain (called Old Fort on the map) a gabbro dike cuts the syenite; two dikes southwest of Chilson cut graphitic sandstone; one dike about a mile west of Chilson cuts sedimentary gneiss; on Moose mountain a very basic gabbro dike cuts anorthosite.

The gabbros can in many localities be traced directly into hornblende schists, or amphibolites, and there is no doubt that many dikes of these gabbros exist. But in some localities, as on Ellis mountain in Hague, dikes are exposed which are purely schistose, with no trace of massive facies. It becomes a matter of some difficulty to determine whether such dikes belong to the syenite intrusion, or to the gabbro, or whether they represent a distinct intrusion in themselves. It is upon the age of these dikes that the relative ages of the syenite and granite depends. The granite is frequently cut by dikes of hornblende schist; if these could be proved to belong to the syenite the relative age would be established. In the localities on the south shore of Pharaoh lake and on the mountain west of Goose pond these schists occur, grading directly into massive gabbros. In the last-mentioned locality are a series of dikes of pure schist, precisely like these questionable ones which so frequently cut the Pharaoh gneiss, but fortunately in one a massive facies was found which placed this set with the gabbros. It is



therefore probable that most of the dikes belong with the gabbro. Nevertheless some of the basic portions of the syenite mass present the mineralogy of a gabbro, and if sheared would pass into amphibolites.

### Summary of evidence of relative age of igneous rocks

The anorthosite is cut by gabbro at Johnson pond and on Moose mountain; the syenite is cut by dikes of gabbro on Bull Rock mountain (called Old Fort on the map), at Chilson, and at the foot of Cat mountain.

The relation between syenite and anorthosite is doubtful, no contacts between the two having been found. Dikes, possibly of syenite, cut anorthosite on Blue Ridge mountain.

The relation between syenite and granite is also doubtful, the two types often appearing to grade into each other.

The granite is cut by dikes of amphibolite; some of these appear to belong with the gabbro; others are altogether doubtful and may belong in age with the syenite.

Gabbro is thus the youngest in age; anorthosite, syenite and granite are undoubtedly of nearly the same age and derived from the same source since they present gradations towards each other. Anorthosite, syenite, granite, is the most probable order of intrusion.

**Pegmatites.** The origin of pegmatites has furnished occasion for much discussion in the past. The close relations of pegmatites to igneous rocks and their occurrence as dikes have led many observers to regard them as true intrusives. On the other hand, their coarse structure and frequent association with quartz veins have led others to the reverse view, namely, that solution was too prominent in their production to admit of an igneous origin; that they are essentially veins, and that they are genetically related to igneous rocks, with more or less of pneumatolytic action at their time of consolidation.

In the northeastern corner of the quadrangle, in the neighborhood of Towner pond, there is limestone in close proximity to intrusive syenite and granite. Contact effects are to be seen in the presence of enormous pegmatites. Roe's spar bed is a famous locality for

minerals,<sup>1</sup> and is a huge pegmatite which has been opened for the economic value of the orthoclase in the manufacture of porcelain. Crystals of biotite, orthoclase and quartz, sometimes over a foot in length, occur at this quarry. Three small diabase dikes cut it, along which are developed tourmaline and titanite. There are several good sized hills consisting of pegmatite in this locality, with smaller pegmatites cutting sedimentary gneiss.

This famous pegmatite can be followed towards the granite intrusion, with increasing biotite as the granite is approached. When followed away from the granite the pegmatite becomes more acid and contains much graphic granite. Small dikes of pegmatite border the mass around the spar bed, these dikes being more acid than the larger ones. Beyond the dikes are veins of rose quartz.

Many pegmatites border the granite of Mount Pharaoh. In this case small dikes only were found. Those near Mount Pharaoh presented the general mineralogy of a granitite, usually with accessory tourmaline or titanite; the more remote ones contained fewer dark silicates.

Pegmatites also occur about the edge of the anorthosite area. These pegmatites contain the same bisilicates as the anorthosite, with quartz, orthoclase and magnetite also.

There seems no doubt that these pegmatites belong to the closing stages of the intrusions; and that they are of igneous origin, but were produced with the aid of more water than their associated plutonics.

On the hills about Crane pond pegmatites are particularly abundant near the limestone contacts, while quartz veins predominate in the quartzose gneiss area. There are complete gradations between the two, though any connection with plutonic sources is here cut off by faults. Professor Van Hise has pointed out<sup>2</sup> that the true explanation of pegmatization includes igneous injection, aqueo-igneous

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<sup>1</sup>Roe's spar bed has been referred to in the following papers: E. H. Williams, *Am. Jour. Sc.* 1881, on tourmaline; J. F. Kemp, *Am. Jour. Sc.* 1888, on minerals near Port Henry; J. F. Kemp on *Geology of Crown Point*, N. Y. N. Y. State Geol. An. Rept for 1893; J. F. Kemp, *U. S. Geol. Survey Bul.* 107, on *Trap Dikes of Lake Champlain*.

<sup>2</sup>C. R. Van Hise. *Principles of Precambrian Geology*. U. S. G. S. 16th An. Rept pt 1. p.684-687.

Plate 13



Faulted dikes, Pharaoh lake



action, and water cementation; that there are all gradations between the three processes, and that under conditions of high temperature and great pressure, water and magma are miscible in all proportions. It would therefore follow that as a center of intrusion was left, the more volatile constituents of the intrusion would be deposited radially and at the same time percolating superheated ground water, containing in solution various constituents from the wall rock, would become mingled with the plutonic material. There would therefore be a gradation between injection processes and cementation.

These old gneisses seem sometimes to have undergone further cementation with no connection with intrusions. Quartz lenses are frequent in the quartzose gneiss, and so is secondary quartz in microscopic quantities. These occurrences belong to the process of cementation of the rock by infiltration of silica in solution. This cementation may have been a continuous process from the time of the first intrusion, but its greatest development must have been subsequent to the main intrusion, for the reason that the intrusions were all too deep seated to be in the zone where percolating water could have had much, if any, effect.

In résumé it may be stated that the plutonics were intruded at great depths, some pegmatites being contemporaneously developed at their periphery. The gradual migration to the surface, through the removal by erosion of the overlying burden, gave increasing opportunity for the action of percolating ground water, and the exact line at which the boundary is to be drawn between dike and vein, or between vein and secondary crevice filling or enlargement of original grains, can not be sharply established.

**Dikes.** Trap dikes have been noted in several localities. The dikes on Pharaoh lake have already been described in the report previously referred to. They are of diabase, and form an anastomosing network running across the strike of the gneiss. These dikes cut pegmatites. They have been more readily weathered than the surrounding gneiss [*see* pl. 10].

There is another diabase dike on the north side of Treadway mountain. It outcrops on the face of a small cliff.



At Roe's spar bed, one mile south of Towner pond, three diabase dikes cut the huge pegmatite exposure. One occurs near Fleming pond, one mile south of Hammondville; another in the gneiss a mile northwest of Penfield pond.

Acid dikes of the type known as Bostonite were found in two localities: one at Heart pond, the other north of Worcester pond. These dikes are bright red and are very small.

**Palaeozoic formations.** *Potsdam sandstone.* As shown on the map, the Potsdam occurs in three localities. Of these the Chilson area is the most important. There are three good outcrops in this area. On the hill near the gabbro are ledges of yellowish quartzite, and not far away in the fields are several small outcrops of conglomerate. The conglomerate and reddish sandstone represent the basal Potsdam. Farther east in the brook is an exposure showing the contact with gneiss. This also is the reddish lower facies. To the south on the road to Putnam pond is an outcrop of a gray color, which represents the upper facies and is slightly calcareous, showing a gradation towards the Calciferous.

These exposures all rest unconformably upon the quartzose gneiss, and the conglomerate contains pebbles of the same gneiss.

The Crown Point area of Potsdam sandstone is a small remnant of the reddish yellow type. It has the usual strike of n. 10 e. and dip of 10 n. w. A pretty little postglacial canyon, with some cascades, is to be seen where the north branch of Putnam creek crosses this Potsdam area. Many loose boulders of Potsdam sandstone and of Calciferous, Chazy and Trenton are scattered about the fields near this locality. These rocks are not glaciated but indicate the former presence of these formations in the valleys.

The exposure on Trout brook shows interesting cutting of the stream channel laterally down the dip, with resulting cliffs on the down-dip side. The rock is the reddish variety, with a strike of n. 20 e. and a dip of 15 n. w.

*Trenton limestone.* In a cut of the abandoned railroad, about a mile west of Ironville, are a series of small exposures of dark gray limestone, containing typical Trenton fossils. A steep and very variable dip, with some variation in strike, points to the possibility

Plate 14



Faulted dikes, Schroon lake



that these rocks were not in place, but since they showed no sign of glaciation they were regarded as probably representing an erosion remnant. An interesting sheared zone was observed in one of these exposures. A strip about an inch wide had been slickensided and completely recrystallized, the many fossils of the side walls completely disappearing. The sheared zone consisted of pure calcite, polysynthetically twinned. The following fossils were identified from this locality:

*Trinucleus concentricus*

*Calymmene senaria*

*Ceraurus pleurexanthemus* (*Green*)

*Bathyurus* (?—)

*Protowarthia cancellata*

*Dalmanella testudinaria*

*Glossina trentonensis* (*Lingula attenuata Conrad*, *L. rectilateralis Emmons*)

*Platystrophia biforata*

**Faults.** Dislocations of varying magnitude are very widespread. As no stratigraphy can be made out the amount of displacement can not be ascertained, nor is the age always capable of determination. A prominent fault cliff extending some five miles in a n. 15 e. direction from Knob mountain has already been noted by Professor Kemp. The breccia of this fault is displayed in a cut of the abandoned railroad. As fine a scarp extends in the same general direction southwards from Bear mountain. There is a general parallelism among the various sets of faults in their general directions, but they often curve through a considerable angle. These northeast-southwest scarps are much the freshest and are probably the latest.

The northwest-bearing fault along the base of Treadway mountain is interesting in that its breccia showed infiltrations of iron oxids bearing pyrite and scales of graphite. The graphite was here undoubtedly formed by a secondary deposition, but was probably derived from the limestone or sandstone. Another set of faults strikes eastwest.

The numerous faults are outlined on the map. Their presence is usually indicated by a cliff, but some of the older ones have weathered so as to be recognizable only from a crushed strip. Many of these may have been overlooked in consequence of the dense vegetation and lack of paths or of outlook.

**Shear zones.** About three miles west of Graphite are three parallel gorges with an east-west direction, the largest of which is locally known as the "Ice gorge." These three gorges are established along three shear-zones. The nearly perpendicular cliffs of the ice gorge are about 500 feet high, while those of the smaller gorges are about 200. The country rock is a porphyritic gneiss, with large orthoclase phenocrysts in a quartzose ground mass, and containing much biotite. The rock from the sheared zones presents a granulation of constituents with an infiltration of iron oxids.

Small faults and shear zones are of almost universal occurrence in this region and traverse all types of rock.

**Foliation.** This structure is common to all the Precambrian rocks, and the general direction of strike is similar. A direction of *n. 40 e.* is the prevailing one, with low southeast dips. Since the direction of foliation is common to all the rocks, it must have a common origin; since no relation is shown between direction of foliation and any of the intrusives, the structure can not be due to igneous agencies. It appears to result from a thrust from the southeast, while the rocks were still deeply buried.

A similar and later thrust when they were nearer the surface appears to be the cause of the faults.

**Joints.** The Precambrian rocks are extensively jointed, the joint planes running in all directions. The joints are usually vertical and as a rule only two sets, nearly at right angles to each other, are present. Occasionally a third, highly inclined joint is present. Their directions are too inconstant to be reduced to any system.

#### PART 4

#### Petrography

It was found difficult to distinguish macroscopically among the basic phases of the three intrusive types—anorthosite, syenite and granite—since with increasing ferro-magnesian minerals they ap-



Plate 15

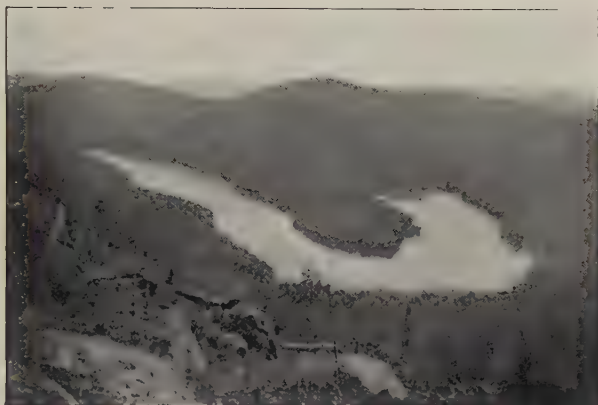


Fig. 1 Gooseneck pond; a faulted rock basin



Fig. 2 Gooseneck pond; a faulted rock basin



proach each other. They also approach very closely to the fourth intrusive type, namely, the gabbro. It was possible, however, to trace these basic developments into masses typical of the classes to which they belonged, and with microscopic work the distinctions became clearer. On the map the areas were colored according to their genetic relationship and they were named according to the most prominent type of a single formation. The map is therefore not lithologically accurate, since rocks that could properly be named *gabbro*, or *diorite*, are included within both syenitic and granitic areas. Only those were mapped as gabbro which could be recognized as distinct in age from the other three intrusions.

The relationships are further complicated by the intense metamorphism, all four types frequently being gneissic. The granitic gneiss approaches the syenitic gneiss on the one hand, the sedimentary hornblende gneiss on the other, while anorthosite gneiss often resembles syenite gneiss or gabbro gneiss. Hence the only possibility of unraveling their relationships is by studying them over wide areas.

The difficulty is further increased in that preglacial valleys were usually established along the contacts, these contacts now being masked by drift and swamp.

The boundaries on the map are therefore subject to some doubt; in some cases several miles of swamp occupy the contact, in others gneisses appear to belong with almost equal accuracy to either of two types. But although the boundaries may be a matter of dispute, it is confidently believed that the high mountains in the northwest consist of anorthosite; that these are bordered on the east and south by a sedimentary belt; that Pharaoh mountain marks the central part of a granite intrusion, and that the mountains of the southwest consist of the syenite.

### Petrography of sedimentary rocks

**Hornblende gneiss.** As before stated, this rock is extremely variable in mineral composition. Streaks of biotite schist are interbedded with it; granite, syenite, anorthosite, pegmatites and trap cut it. The country rock itself is variable in composition, and has

been highly metamorphosed and recrystallized. Thin sections of this rock from Mount Treadway exhibit quartz, feldspar, hornblende, biotite, piedmontite, magnetite and ilmenite. There is every evidence of intense metamorphism. The quartz is strained, with undulatory extinction. The feldspar is mainly microcline, with subordinate plagioclase, and both feldspars show strain effects. Anorthoclase is often present. The plagioclase is usually oligoclase, but both albite and labradorite are sometimes found. Large pink garnets are sometimes present. The biotite is a very black variety, pleochroic from black to pale brown, and often exhibiting pleochroic halos. The piedmontite is small in amount, but is present in nearly all the slides examined of this type of rock.

Considerable variation in the amount of metamorphism is to be seen in this series, and some variation in the relative quantities of constituents. On Third Brother the maximum of strain is reached; some of the feldspars are bent through a large angle, and all feldspar and quartz show undulatory extinction. Microcline is the predominating feldspar. Piedmontite is abundant. Several brecciated zones were found on the sides of the mountain and near its top; at first sight they resembled serpentine dikes, but closer study showed them to be small shear zones. These fault breccias showed prevailing secondary minerals, quartz, epidote, chlorite and related minerals. Faint traces of hornblende were made out, nearly altered to chlorite with finely divided epidote and calcite. The plagioclase was completely altered to kaolin and saussurite. Some magnetite is present. Precisely similar rock occurs northwest of Penfield pond, and on the hill northeast of Paradox lake. The commonest type is somewhat less strained, with hornblende and biotite in about equal amounts, and with microcline, plagioclase and orthoclase in decreasing order of abundance. Quartz is always the most common mineral.

On the mountain erroneously called Trumbull on the map (the local name is Ellis) is found the least altered variety of this rock. No microcline was present, but a larger proportion of orthoclase altering to kaolin and zeolites. The quartz was less strained; the biotites showed no halos; no piedmontite was found.

The quartz usually constitutes about 40% of the rock; feldspar over 50%; the remaining dark silicates being thus small in quantity. Unfortunately the rock was invariably too greatly weathered for an analysis to be accurate, but it is confidently believed that if such an analysis could be made the silica content would be high enough to place the rock without doubt among the sediments.

The biotite schist which forms bands in this gneiss and in the limestone is found to contain large quantities of quartz. Quartz forms from 20% to 30% of the rock and biotite is present in about the same amount. The remainder of the rock is made up of feldspars (microcline, albite, labradorite and oligoclase all being found, usually one variety predominating and one other being less in amount), garnet, zircon, apatite, and magnetite, in varying proportions.

The probability concerning this gneiss is that it represents the base of the Grenville series, which has suffered from the metamorphism common to the region as a whole, and which has experienced in addition an excessive amount of recrystallization and squeezing from being nearest to the intrusives.

**Sillimanite gneiss.** Thin sections of the rock at Graphite show large garnets embedded in a mass of fibrous sillimanite. The sillimanite crystals show a roughly parallel arrangement. A little quartz is present and accessory zircon, pyrite and graphite. The foot and hanging wall are similar, except that the foot wall contains microperthite in addition to the minerals found in the hanging wall.

The sillimanite gneiss from Bear Pond mountain contains similar shreds of sillimanite. Biotite is present in large quantities, the biotite being younger than the sillimanite. In the prevailing type shreds of biotite and of sillimanite are arranged in parallel groups, the terminal faces of both being lacking. Occasionally a sillimanite crystal is found cutting across the biotite at right angles to its long axis, and in such cases it is the sillimanite that has the perfect boundary. Accessory pyrite and rutile are sometimes present.

### **Petrography of the igneous rocks**

Of the four types of igneous crystalline rocks found on the Paradox Lake quadrangle—granite, syenite, anorthosite, and gabbro—



only two, the anorthosite and gabbro, were recognized as intrusives in the preliminary report on the region. The granite and syenite together constituted a "doubtful" area which was, for convenience, called "Series I," the presumption being that they were older than the limestone and possibly to be correlated with the Ottawa gneiss of Canada.

**Granite.** The granite of the Paradox Lake quadrangle is usually gneissic.

It is believed to be igneous because of its constant composition over wide areas; it is regarded as intrusive into and younger than the sedimentary hornblende gneiss because of the small dikes and pegmatites which appear to radiate from the granite, cutting the sedimentary gneiss.

In no case could a true intrusive contact be found. In most localities where the two gneisses come together, or where the massive granite gneiss is in contact with the limestone, faulting is found to be the cause. Where there is no fault in evidence, the contact is obscured by swamps.

In mineralogy this granite-gneiss is very constant. It contains hornblende, orthoclase, plagioclase and quartz, with occasional accessory biotite, muscovite, magnetite, pyroxene, apatite and zircon. Some slides of this rock present the normal appearance of a hornblende granite, but usually the minerals are drawn out into gneissic bands, the orthoclase changed to microcline; the quartz showing undulatory extinction; the hornblende bent and twisted but unaltered optically. Tiny shear zones are common, filled with secondary quartz, chlorite or zeolites. Secondary garnets are occasionally present, but are not so common as in the more basic rocks. Inter-growths of quartz and orthoclase (micro-perthite) are common.

Another variety is porphyritic, with phenocrysts of orthoclase.

Still another variety is that which contains the Hammondville ores. This type is conspicuous in the absence of ferro-magnesian minerals, consisting mainly of quartz, microperthite and plagioclase. A scattering of magnetite grains with very rare hornblende are present as slight accessories. The hornblende is usually brown. Occasionally the green variety is found.

Plate 16



Mt Pharaoh, from Crane pond. Granite gneiss



The quartz sometimes occurs in grains, but more often, especially in the crushed varieties, in lenses. Evidently in some cases the quartz has been enriched secondarily.

The structure is frequently cataclastic, the constituents appearing to be in grains resulting from the crushing of larger crystals. The rocks possessing this structure pass by insensible gradations into true granites, and there can be little doubt that the gneisses exhibiting this structure are crushed portions of the granite.

The rock found in Pharaoh mountain is the most wide-spread type. It presents a general pink appearance in the hand specimen, and under the microscope proves to be a hornblende-granite-gneiss.

The Pharaoh type contains about 50% of feldspar. Predominating orthoclase, with accessory albite or oligoclase, is probably the normal composition, but these have usually been replaced by microcline and microperthite. Primary quartz constitutes about 30% of the rock, although the actual quartz content is almost always increased by the presence of secondary lenses and veinlets. The remaining 20% is made up of hornblende and the accessory minerals.

**Syenite.** As already mentioned, the syenite of the Paradox region belongs to the syenite type of Cushing and of Smyth. The preliminary reports on the Paradox region were published before this type was recognized, and it was included within the "doubtful" area.

In thin section a cataclastic structure is commonly found. There is much variation in mineral contents, there being a complete gradation from an augite syenite containing microperthite to a type closely resembling the granite and consisting essentially of hornblende, microperthite, subordinate augite, quartz and a little biotite. There is constant likeness between this type and the granite of Mount Pharaoh in the presence of intergrowths of several different minerals. Microperthite (consisting of intergrowths of orthoclase and albite) is a normal component, and less frequently there occurs (in the syenite only) an intergrowth of green augite with bronzite or hypersthene. Quartz is usually present in the syenite, and its often elongated lens-like form suggests that it is secondary. Some primary quartz is present also. The pyroxene is a bright emerald green variety.

The syenite from the southeastern area contains as essential minerals microperthite, a deep green nonpleochroic augite, small amounts of hornblende and of quartz, with accessory apatite, magnetite, zircon and garnet, the last named perhaps secondary.

The syenite from the area on the eastern shore of Schroon lake contains relatively more hornblende and more quartz.

In the Crown Point area labradorite is present in addition to microperthite.

Within the anorthosite area of the Blue Ridge, about a mile from the boundary of the syenite, are three dikes which cut the anorthosite. These dikes contain green augite, labradorite, and very abundant garnet. They appear to belong with the syenite intrusion, and if so, would indicate that the syenite is younger than the anorthosite.

**Anorthosite.** Anorthosite is a coarse grained rock of the gabbro family, presenting the extreme of the series rich in feldspar. Some occurrences consist of pure plagioclase.

In its massive phases the rock is quite fresh. The plagioclase is twinned according to both pericline and albite laws. It is always labradorite. Hypersthene, pleochroic from pink to green, and a pale green, normal augite are the only other minerals which occur in appreciable quantities. The structure is irregular, the bisilicates being grouped together and not evenly distributed through the rock. Associated with the grouping of constituents is a variation in size of grain. When crushed, the dark patches are pulled out into lenticles, or into gneissoid banding. Similar sudden variations in texture have been noted by Professor G. H. Williams, in the Baltimore gabbros.<sup>1</sup>

Hornblende, biotite and orthoclase may be present in small quantities, with accessory or secondary magnetite, titanite, ilmenite, apatite, chlorite, epidote, garnet, zircon and spinel.

An extensive series of metamorphic effects can be seen. In the northwestern portion of the quadrangle the rock is uniformly massive, except when brecciated by faulting. The labradorite crystals

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<sup>1</sup>G. H. Williams. "The Gabbros and Associated Hornblende Rocks Occurring in the Neighborhood of Baltimore, Maryland." U. S. G. S. Bul. 28.



show their characteristic irridescence and are an inch or more in length. Farther south and east, along a zone beginning a few miles from the border of the intrusion, the rock is granulated and a cataclastic structure is seen in thin section. If present, the bisilicates are drawn out into irregular bands. If slightly more crushed the rock becomes a gneiss, and as the granulated labradorite is white, it becomes a matter of some difficulty to distinguish in hand specimens between gneissic anorthosite and the sedimentary gneiss. It was this banding which led Emmons to claim a sedimentary origin for the rock. The extreme of metamorphism is seen in a complete mashing and the development of new minerals. On the hill northwest of Paradox lake is a variety which in the hand specimen is an even white color, with no constituent minerals distinguishable, and with large secondary garnets embedded in the white mass. In thin section this white rock is found to consist of broken pieces of plagioclase, and in general the whiter the rock the more complete the granulation. The completely granulated rock resembles a massive limestone. If ferro-magnesian minerals are present they may be drawn out into gneissic bands with a cataclastic structure. Garnet, secondary after pyroxene, often occurs. These intensely granulated anorthosites frequently contain titaniferous iron ore. Prof. Frank D. Adams<sup>1</sup> has suggested that these ore bodies may be due to a gathering together, from crushing, of minute inclusions previously contained in the feldspar. The area in Canada which he describes is remarkably similar to the one under consideration, but the Adirondack area does not contain such an extensive amount of black dust in its labradorite. Titaniferous magnetite occurs in occasional crystals in the massive anorthosite, and its formation appears to be that of a local gathering together of constituents analogous to that of the grouping of the bisilicates. The dark silicates are more abundant in the peripheral portion of the intrusion.

The irregularities in size of grain and in distribution of constituents must be due to processes taking place during consolidation. Whether the processes are chemical in their nature or physical, or

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<sup>1</sup>F. D. Adams. Geol. Survey of Canada; Rept J. 1895. v.8.

whether varying specific gravity of the minerals is a factor in their localization is yet to be demonstrated. The granulation of the massive rock and the gneissic banding are undoubtedly secondary effects, having taken place after the consolidation of the rock as a result of pressure.

Garnet is the only undoubtedly secondary mineral present except those which are subsequently caused by a local shear. The occurrence of such intense granulation without a corresponding change in mineralogy (augite to hornblende or uraltite, feldspar to saussurite and albite, etc.) is unusual. Prof. Frank D. Adams, in the report already cited, suggests that movement must have taken place while the rock was deeply buried and at a high temperature. The deep burying accounts for the absence of shearing effects; the high temperature for the lack of secondary hornblende, which needs low temperature for its production. The Adirondack occurrence is precisely similar to the Canadian one here described.

**Gabbro.** The gabbro proper is a basic variety, consisting of labradorite, green monoclinic augite, titanite, sometimes hypersthene and occasionally olivine. It usually presents an ophitic texture, with broad laths of feldspar which have the ferro-magnesian constituents between them. With increasing hypersthene the gabbros pass into norites; with increasing ilmenite and titaniferous magnetite the gabbro passes into the titaniferous iron ores.

The anorthosite and gabbro illustrate the familiar truth that basic rocks are more liable to vary than acid ones. The gabbro family appears to be particularly variable, as is evident from a comparison of the mineralogy of the various types. The gradation from a pure labradorite rock on the one hand to a titaniferous iron ore on the other is a much greater change mineralogically and chemically than is ever known in so small an area among granitic rocks.

The gabbro area near Johnson pond presents a series of gradations from a dark garnetiferous gabbro to a labradorite rich variety, which is practically a pyroxenic anorthosite. In the northern part of this area the more typical gabbro occurs, and its contact with the anorthosite is distinct and suggestive of an intrusion of the gabbro into the anorthosite. In the southern part, however, on Peaked hill,

there is considerable confusion, gabbroic bands alternating with anorthosite in an astonishing manner. The southern and eastern boundary of the area was difficult to determine because of this alternation and gradation of types. In the extreme eastern portion of the area mapped as gabbro there is a rock which seems to represent crushed gabbro. It consists of garnet, of almost microscopic size, which gives the rock in the hand specimen the appearance of a granular aggregate of little garnets. The same rock is found in a series of dikes on top of the mountain 1742 feet high, slightly north of east of Peaked hill.

In thin section the garnet rock is found to be a true gabbro, containing green pyroxene, labradorite, diallage, titaniferous magnetite and garnet. These small dikes differ from the commoner bosses in being of finer grain; in having relatively greater abundance of garnets, and in the presence of diallage.

The occurrence of the small garnetiferous dikes in the anorthosite, and also along the contacts of gabbro and anorthosite, suggests their peculiar structure as due to contact effects. They are certainly a part of the gabbro intrusion, and their occurrence indicates that the gabbro is later than the anorthosite.

The gabbros are usually crushed, and then develop gneisses which can not be distinguished from the gneissic development of the gabbro phase of the anorthosite, nor from the gabbroic part of the syenite, nor from some areas found among the granites.

The gabbros are frequently granulated and show gradations similar to those seen in the anorthosite. There appears also to have been recrystallization in the gabbros. The plagioclase contains many fine black inclusions which may be either pyroxene or titaniferous magnetite, or both. They are apparently inclusions, not alteration products. Similar inclusions have been described by many writers on gabbros.<sup>1</sup> Reaction rims are common.

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<sup>1</sup>G. H. Williams. U. S. G. S. Bul. 28.

F. D. Adams. Über das Norian oder Ober-Laurentian von Canada. Neues Jahrbuch. Band 8, p.425.

A. C. Lawson. Anorthosites of the Minn. Coast of Lake Superior. Minn. Geol. Survey Bul. 8. 1893. p.8.

J. F. Kemp. Gabbros on the Western Shore of Lake Champlain. Bul. Geol. Soc. Am. 5:213-24.

### Summary and conclusions

The investigation of the gneissic area resulted in showing the possibility of splitting up the "doubtful gneiss" of earlier reports into three types: (1) Syenite, which is igneous in origin and is in all respects similar to the syenite previously described in other Adirondack localities. (2) Granite. (3) Quartzose gneiss of sedimentary origin, which may be the rock that has sometimes been termed "gneiss of the limestone series." The syenite is without doubt a plutonic igneous rock, and although gneissic phases are common, completely massive ones predominate. The granite is more completely gneissic, and for that reason there is less certainty in determining it. Both syenite and granite are alike in presenting variations in the percentages of ferro-magnesian constituents. The third type of gneiss is the most highly metamorphosed. It contains so many intrusions of small size both of syenite and of granite that it was found impossible to mark them off in mapping. It was further altered by secondary infiltration of quartz, both in the form of large veins and of disseminations of microscopic size.

The presence of these small intrusions affords evidence that the granite and syenite are younger than the quartzose gneiss; and the character of the rock, its macroscopic and its microscopic appearance, and the topography of its mountains point toward a sedimentary origin. Its frequent association with the limestone (occurring sometimes in thin layers folded with the limestone, sometimes in hills while the limestone occupies the intervening valleys) points toward the conclusion that this quartzose gneiss is a member of the limestone series. Since this gneiss underlies the limestone, and also underlies the other gneisses which are of sedimentary origin, it is thought to represent the base of the Grenville series. In its basal position is to be found the explanation of the great number of intrusive masses which render this rock so difficult of interpretation in the field. Being at the bottom of the sediments, it formed the portion most subject to alteration from the intrusions, and it now contains within its mass remnants of what were apophyses from the top of the intrusions.



Of the relative ages of the intrusives, the only evidence is that of somewhat doubtful dikes. Some of the dikes are undoubtedly gabbro and cut all the other Precambrian intrusives; others may be syenites and cut anorthosite, and possibly granite. Granted that these dikes cutting granite are not syenite, the field relations point strongly to the younger age of the granite. Both in this region and elsewhere<sup>1</sup> the syenite is bordered by granite, the granite being much more gneissic than the syenite. Gradations between the two are common. It seems most reasonable to regard the granite as a border development of the syenite, derived from the same magma, and very slightly younger in age.

Regarded from this point of view the Adirondacks form a well marked petrographic province, presenting rocks with very great variations in composition, grading from ultrabasic to acid, but all to be regarded as derived from one magma by differentiation.

The great complexity of Adirondack structure results from the fact that these intrusives, together with the sediments of the Grenville series, into which they were intruded, have all been crushed so as to present similar planes of foliation, and at a later time have been extensively faulted.

## PART 5

### Economic geology

**Graphite.** Graphite and iron ores are the only products of economic importance. The graphite is mined at two localities, and occurs in many places on the quadrangle. The demand for graphite in fine scales is limited, hence the industry has not developed to the full extent of the workable material. The mines at the town of Graphite have already been described by Professor Kemp;<sup>1</sup> the graphite there occurs as drawn-out flakes among quartz grains in a layer bounded above and below by the garnet-sillimanite gneiss. There has been faulting, and the graphite has suffered from a shear along the bedding. At Rock pond, where a small mine has recently

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<sup>1</sup>H. P. Cushing. "Recent Geologic Work in Franklin and St. Lawrence Counties." N. Y. State Geol. 20th An. Rept 1902. p. 123-182.

<sup>2</sup>N. Y. State Geol. 17th An. Rept 1899. p. 539.



been opened, it also occurs along a line of movement in a gneiss which is probably of sedimentary origin but is not graphitic. In various other localities prospect holes have been opened, and wherever successful there is evidence of shearing. The sandstones and limestones which are charged with small amounts of graphite are not far from all of these openings, but the wall rock is apparently never a markedly graphitic one. Less than half a mile east of the Rock pond locality the graphitic sandstone occurs on North pond; the drill cores at Graphite went through graphitic limestone. It therefore appears as though the graphite deposits were a result of impregnation along a line of weakness by some products, possibly volatile hydrocarbons, originating from the distillation of originally fossiliferous sediments.

Thin sections of the shear zone at the western front of the cliffs of Treadway mountain reveal flakes of graphite. The bounding rock is the quartzose gneiss of probable sedimentary origin, and the graphite flakes appear secondary and are evidently related to an infiltration of iron-charged solutions. Pyrite invariably occurs associated with the graphite, and sometimes limonite and magnetite as well. Any theory of the origin of graphite must explain its association with these iron compounds.

Dr Ernst Weinschenk has recently published a series of papers entitled "*Zur Kenntniss der Graphitlagerstätten*," in which he takes up occurrences of graphite in various European localities. He finds that graphite may occur either as a result of contact metamorphism from a large intrusion of any kind into a calcareous formation, or from injection in gaseous condition along planes of weakness in a disturbed area. He finds that graphite is never to be regarded as the final step in the process of coal formation, and that at least in the Alps and in Ceylon the graphite is not due to regional or to dynamic metamorphism.

The Adirondack graphite is plainly of two kinds: that present as an accessory constituent of the limestone and quartzite, and that occurring in a secondary position along fault lines. The latter occurrence appears analogous to that described by Weinschenk as

Plate 17



A graphite nodule in limestone. Ironville road



intrusive along planes of weakness, and can only be explained as an injection of carbonaceous and ferruginous materials in a fluid or gaseous condition. A reducing action of iron compounds on hydrocarbons might result in the formation of the graphite and pyrite which we constantly find associated.

But the widespread dissemination of graphite scales in sedimentary limestone and quartzite can best be explained on the organic hypothesis. There seems no possibility of any origin but that of a metamorphic product from some original constituent of the rock, and regional metamorphism is the only process by which it can reasonably be supposed to have been formed. It seems most probable that the original limestone and sandstone were heavily charged with organic material which in the Prepottsdam period of metamorphism was completely reduced and in some part volatilized. The organic material thus reduced remains in its original position as graphite, while the volatilized portions spread along every available plane of weakness and form the deposits of economic importance.

**Titaniferous magnetite.** Titaniferous iron ores appear on Moose mountain. The occurrence of these ore bodies is evidently to be explained in the same way as the aggregation of minerals in the anorthosites. The titaniferous ores always occur in the anorthosite, or gabbro, and represent the extreme development in the direction of producing an aggregation of iron minerals. The process is entirely analogous to that of the production of anorthosite from gabbro by increase in feldspar, or of pyroxenite from gabbro by the decrease in augite. There is no evidence of intrusion, nor of vein formation in the occurrence of these ores, nor have they any relation to faults or crushed zones. The titaniferous iron ores of the Adirondacks have been fully treated by Professor Kemp.<sup>1</sup>

**Nontitaniferous magnetites.** Reference has already been made in Professor Kemp's preliminary report<sup>2</sup> to the magnetite deposits of Hammondville and to the Schofield ore body. Both deposits occur in the granite of a type containing almost no ferro-magnesian

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<sup>1</sup>U. S. G. S. 19th An. Rept pt 3. Economic Geology. p.379-422.

<sup>2</sup>Geology of Essex County. N. Y. State Geologist An. Rept for 1893 and 1895.

minerals. Both localities are very extensively faulted; the face of Skiff mountain shows a fault cliff, and at Hammondville fault breccias are of frequent occurrence.

Magnetite was found by the writer in the Desolate brook valley, southwest of Pharaoh mountain. It had been tapped by a mine, apparently long abandoned. The foot and hanging walls were of the same type of granite as those of the former localities.

These deposits are in striking contrast to the titaniferous ore bodies, the magnetites showing no intimate relation to the wall rock. The conclusion seems inevitable that they are foreign to the granite, and produced in connection with one of the later intrusions, probably secondarily enriched by percolating water. Similar ores near Port Henry<sup>3</sup> have been described by Professor Kemp. There the ores are associated with an igneous intrusion of gabbro; they are always within an acid gneiss, but their proximity to the gabbro renders their origin as contact occurrences the most reasonable view.

The Hammondville and Schofield ore bodies are cut off by faults from all neighboring intrusions, but their most probable relationship seems to be with intrusive action.

The alternative hypotheses would be either to regard the magnetite as a metamorphosed sedimentary bed and the Hammondville gneiss as a sediment, which is improbable in view of its similarity to the Pharaoh granite; or else to consider it a magmatic segregation from the granite, which seems improbable in so acidic a rock, notably poor in iron.

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<sup>3</sup>J. F. Kemp. Geology of the Magnetites near Port Henry N. Y. and especially those of Mineville. Trans. Am. Inst. Min. Eng. 1897.



# INDEX

The superior figures tell the exact place on the page in ninths; e. g. 500<sup>3</sup> means page 500, beginning in the third ninth of the page, i. e. about one third of the way down.

**Adams**, Frank D., cited, 499<sup>6</sup>, 500<sup>3</sup>, 501<sup>8</sup>.

**Adirondacks**, topography and geology, 461<sup>7</sup>-63<sup>2</sup>; faulted region, 462<sup>2</sup>; trellised drainage, 462<sup>4</sup>; recent geologic work, 463<sup>2</sup>.

**Albite**, 494<sup>3</sup>, 495<sup>3</sup>, 497<sup>4</sup>.

**Anorthosite**, 483<sup>7</sup>, 485<sup>5</sup>-86<sup>2</sup>, 493<sup>9</sup>, 495<sup>9</sup>, 500<sup>9</sup>, 503<sup>2</sup>; description, 498<sup>4</sup>-500<sup>8</sup>.

**Apatite**, 495<sup>4</sup>, 496<sup>6</sup>, 498<sup>1</sup>, 498<sup>8</sup>.

**Augite**, 497<sup>7</sup>, 497<sup>8</sup>, 498<sup>1</sup>, 498<sup>3</sup>, 498<sup>6</sup>, 500<sup>5</sup>.

**Biotite**, 494<sup>1</sup>, 494<sup>3</sup>, 494<sup>7</sup>, 494<sup>9</sup>, 495<sup>3</sup>, 495<sup>7</sup>, 496<sup>6</sup>, 497<sup>7</sup>, 498<sup>4</sup>.

**Biotite schist**, 493<sup>9</sup>, 495<sup>2</sup>.

**Brigham**, cited, 462<sup>4</sup>.

**Bronzite**, 497<sup>8</sup>.

**Calciferous** outlier, 467<sup>9</sup>.

**Calcite**, 494<sup>7</sup>.

**Cambric** drainage lines, 465<sup>5</sup>-67<sup>9</sup>.

**Chilson lake**, valleys, 466<sup>8</sup>.

**Chlorite**, 494<sup>6</sup>, 494<sup>7</sup>, 496<sup>7</sup>, 498<sup>8</sup>.

**Cirques**, 476<sup>1</sup>.

**Crown Point**, 470<sup>9</sup>-72<sup>5</sup>.

**Cushing**, H. P., work on the geology of the Adirondacks, 463<sup>4</sup>; cited, 469<sup>4</sup>, 484<sup>9</sup>, 503<sup>9</sup>; mentioned, 483<sup>7</sup>.

**Desolate** brook, 477<sup>3</sup>.

**Diallage**, 501<sup>3</sup>.

**Dikes**, 489<sup>8</sup>-90<sup>2</sup>, 503<sup>1</sup>.

**Drainage** modifications, 469<sup>7</sup>-78<sup>4</sup>.

**Economic** geology, 503<sup>6</sup>-6<sup>7</sup>.

**Emmons**, E., geologic work on the Adirondacks, 463<sup>3</sup>; cited, 472<sup>6</sup>, 499<sup>3</sup>.

**Epidote**, 494<sup>6</sup>, 494<sup>7</sup>, 498<sup>8</sup>.

**Faults**, 491<sup>5</sup>-92<sup>2</sup>.

**Feldspar**, 494<sup>1</sup>, 494<sup>2</sup>, 494<sup>5</sup>, 495<sup>1</sup>, 495<sup>3</sup>, 497<sup>4</sup>, 498<sup>4</sup>, 500<sup>6</sup>.

**Foliation**, 492<sup>5</sup>.

**Gabbro**, 486<sup>3</sup>-87<sup>2</sup>, 495<sup>9</sup>, 498<sup>7</sup>, 503<sup>1</sup>; description, 500<sup>6</sup>-1<sup>9</sup>.

**Garnets**, 494<sup>3</sup>, 495<sup>4</sup>, 496<sup>7</sup>, 498<sup>2</sup>, 498<sup>4</sup>, 498<sup>8</sup>, 499<sup>4</sup>, 499<sup>5</sup>, 500<sup>2</sup>, 501<sup>2</sup>, 501<sup>4</sup>.

**Glacial** deposits, 469<sup>7</sup>-78<sup>4</sup>.

**Glaciology** of the Paradox Lake quadrangle, 465<sup>5</sup>-78<sup>4</sup>.

**Gneiss**, 479<sup>2</sup>; defined, 479<sup>9</sup>; hornblende, 479<sup>2</sup>, 493<sup>9</sup>-95<sup>5</sup>; quartzose, summary and conclusions, 502<sup>1</sup>-3<sup>5</sup>; sillimanite, 479<sup>2</sup>, 481<sup>7</sup>-83<sup>1</sup>, 495<sup>6</sup>.

**Granite**, 484<sup>4</sup>, 493<sup>9</sup>, 495<sup>9</sup>, 503<sup>2</sup>; description, 496<sup>2</sup>-97<sup>5</sup>; summary and conclusions, 502<sup>1</sup>-3<sup>5</sup>.

**Graphite**, 495<sup>6</sup>, 503<sup>7</sup>-5<sup>5</sup>.

**Grenville** series, sediments of, 479<sup>1</sup>.

**Grooves**, 476<sup>1</sup>.

**Hague**, 475<sup>9</sup>-77<sup>2</sup>.

**Horicon**, 477<sup>2</sup>.

**Hornblende**, 479<sup>2</sup>, 494<sup>1</sup>, 494<sup>6</sup>, 494<sup>7</sup>, 496<sup>6</sup>, 496<sup>9</sup>, 497<sup>5</sup>, 497<sup>7</sup>, 498<sup>1</sup>, 498<sup>2</sup>, 498<sup>8</sup>.

**Hornblende gneiss**, 479<sup>2</sup>; description, 493<sup>9</sup>-95<sup>5</sup>.

**Hudson**, north, 477<sup>5</sup>.

**Hypersthene**, 497<sup>9</sup>, 498<sup>5</sup>, 500<sup>5</sup>, 500<sup>6</sup>.

**Igneous** rocks, summary of evidence of relative age, 487<sup>2</sup>-92<sup>8</sup>; petrography of, 495<sup>9</sup>-501<sup>9</sup>.

**Ilmenite**, 494<sup>1</sup>, 498<sup>3</sup>, 500<sup>6</sup>.

**Intrusives**, 483<sup>6</sup>-84<sup>4</sup>; relative ages, 503<sup>1</sup>.

**Iron** ores, 503<sup>7</sup>.

**Joints**, 492<sup>7</sup>.

**Kames**, 472<sup>5</sup>.

**Kaolin**, 494<sup>7</sup>, 494<sup>9</sup>.

**Kemp**, J. F., acknowledgments to, 461<sup>6</sup>; work on the geology of the Adirondacks, 463<sup>3</sup>; cited, 465<sup>9</sup>, 481<sup>7</sup>, 488<sup>8</sup>, 491<sup>6</sup>, 501<sup>9</sup>, 503<sup>8</sup>, 505<sup>8</sup>, 506<sup>4</sup>.

- Labradorite**, 494<sup>3</sup>, 495<sup>3</sup>, 498<sup>2</sup>, 498<sup>3</sup>, 498<sup>5</sup>, 498<sup>9</sup>, 499<sup>2</sup>, 499<sup>7</sup>, 500<sup>5</sup>, 500<sup>8</sup>, 501<sup>3</sup>.  
 Lawson, A. C., cited, 501<sup>9</sup>.  
 Limestone, 479<sup>2</sup>, 479<sup>6</sup>.  
 Limonite, 504<sup>3</sup>.  
 Lower base-level, age of, 469<sup>4</sup>.
- Magnetite**, 494<sup>1</sup>, 494<sup>7</sup>, 495<sup>4</sup>, 496<sup>6</sup>, 496<sup>9</sup>, 498<sup>2</sup>, 498<sup>3</sup>, 504<sup>5</sup>; nontitaniferous, 505<sup>8-67</sup>; titaniferous, 499<sup>7</sup>, 500<sup>6</sup>, 501<sup>3</sup>, 501<sup>7</sup>, 505<sup>5</sup>.  
 Mica schist, 479<sup>2</sup>, 480<sup>9-817</sup>.  
 Microcline, 494<sup>2</sup>, 494<sup>5</sup>, 494<sup>8</sup>, 495<sup>3</sup>, 496<sup>7</sup>, 497<sup>4</sup>.  
 Microperthite, 495<sup>7</sup>, 496<sup>8</sup>, 496<sup>9</sup>, 497<sup>4</sup>, 497<sup>7</sup>, 497<sup>8</sup>, 498<sup>1</sup>, 498<sup>3</sup>.  
 Muscovite, 496<sup>6</sup>.
- Newland**, D. H., work on the geology of the Adirondacks, 463<sup>6</sup>.  
 Norites, 500<sup>6</sup>.
- Oligoclase**, 495<sup>3</sup>, 497<sup>4</sup>.  
 Orthoclase, 494<sup>8</sup>, 494<sup>9</sup>, 496<sup>6</sup>, 496<sup>8</sup>, 497<sup>4</sup>, 498<sup>8</sup>.
- Paleozoic formations**, 490<sup>3-915</sup>.  
 Paradox Lake quadrangle, location and topography, 464<sup>1-654</sup>; physiography and glaciology, 465<sup>5-784</sup>.  
 Pegmatites, 487<sup>6-897</sup>, 493<sup>9</sup>.  
 Peneplains, 468<sup>1</sup>.  
 Petrography, 492<sup>9-5036</sup>; of sedimentary rocks, 493<sup>8-959</sup>; of igneous rocks, 495<sup>9-5019</sup>.  
 Pharaoh lake, 477<sup>2</sup>.  
 Physiography of the Paradox Lake quadrangle, 465<sup>5-784</sup>.  
 Piedmontite, 494<sup>1</sup>, 494<sup>3</sup>, 494<sup>5</sup>.  
 Plagioclase, 494<sup>2</sup>, 494<sup>8</sup>, 496<sup>6</sup>, 496<sup>9</sup>, 498<sup>5</sup>, 499<sup>4</sup>.  
 Porphyritic gneiss, 496<sup>8</sup>.  
 Potsdam sandstone, 466<sup>3</sup>, 478<sup>6</sup>, 490<sup>3</sup>.  
 Preglacial erosion history, summary of, 468<sup>6-694</sup>.  
 Putnam creek valley, 466<sup>8</sup>.  
 Pyrite, 495<sup>6</sup>, 495<sup>9</sup>, 504<sup>5</sup>.  
 Pyroxene, 496<sup>6</sup>, 497<sup>9</sup>, 499<sup>6</sup>, 501<sup>3</sup>, 501<sup>7</sup>.
- Quartz**, 494<sup>1</sup>, 494<sup>5</sup>, 494<sup>6</sup>, 494<sup>8</sup>, 494<sup>9</sup>, 495<sup>1</sup>, 495<sup>3</sup>, 495<sup>6</sup>, 496<sup>6</sup>, 496<sup>9</sup>, 497<sup>1</sup>, 497<sup>4</sup>, 497<sup>7</sup>, 497<sup>9</sup>, 498<sup>1</sup>, 498<sup>2</sup>.  
 Quartzite, graphitic, 479<sup>2</sup>; shaly, 479<sup>2</sup>, 483<sup>2</sup>.  
 Quartzose gneiss, summary and conclusions, 502<sup>1-35</sup>.
- Rutile**, 495<sup>9</sup>.
- Saussurite**, 494<sup>7</sup>.  
 Schroon valley, 466<sup>9</sup>, 477<sup>2</sup>.  
 Sedimentary rocks, petrography of, 493<sup>8-959</sup>.  
 Shaly quartzite, 483<sup>2</sup>.  
 Shear zones, 492<sup>2</sup>.  
 Sherman Corners, valley near, 466<sup>8</sup>.  
 Sillimanite gneiss, 479<sup>2</sup>, 481<sup>7-831</sup>; description, 495<sup>6</sup>.  
 Smyth, C. H. jr, work on the geology of the Adirondacks, 463<sup>4</sup>; mentioned, 483<sup>7</sup>; cited, 484<sup>8</sup>.  
 Spinel, 498<sup>8</sup>.  
 Stratigraphic relations, summary of, 483<sup>5</sup>.  
 Syenite, 484<sup>8-855</sup>, 493<sup>9</sup>, 495<sup>9</sup>, 503<sup>2</sup>; description, 497<sup>5-984</sup>; summary and conclusions, 502<sup>1-35</sup>.
- Ticonderoga**, 472<sup>5-771</sup>.  
 Titaniferous iron ores, 500<sup>6</sup>.  
 Titaniferous magnetite, 499<sup>7</sup>, 500<sup>6</sup>, 501<sup>3</sup>, 501<sup>7</sup>, 505<sup>5</sup>.  
 Titanite, 498<sup>8</sup>, 500<sup>5</sup>.  
 Topography of the Paradox Lake quadrangle, 464<sup>1-654</sup>.  
 Towner pond, 472<sup>1</sup>.  
 Trap, 493<sup>9</sup>.  
 Trap dikes, 489<sup>8</sup>.  
 Trenton limestone, 490<sup>9-915</sup>.  
 Trout brook valley, 466<sup>7</sup>, 476<sup>6</sup>.
- Van Hise**, cited, 488<sup>8</sup>.
- Weinschenk**, Ernst, cited, 504<sup>6</sup>.  
 Whortleberry pond, 477<sup>2</sup>.  
 Williams, E. H., cited, 488<sup>8</sup>.  
 Williams, G. H., cited, 498<sup>7</sup>, 501<sup>8</sup>.  
 Wolf pond, 477<sup>2</sup>.
- Zeolites**, 494<sup>9</sup>, 496<sup>7</sup>.  
 Zircon, 495<sup>4</sup>, 495<sup>6</sup>, 496<sup>6</sup>, 498<sup>2</sup>, 498<sup>3</sup>.

# New York State Education Department

## New York State Museum

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| 6        | 57, v.1 | Z 3      | 53, v.1 | 20       | " v.1         | 8        | 57, v.2 |
| Eg 5, 6  | 48, v.1 | 4        | 54, v.1 | 21       | " v.1         | 9        | " v.2   |
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| 10       | " v.3   | 10       | 57, v.1 | 5        | 55, v.1       | 3, 4     | 53, v.2 |
| 11       | 56, v.1 | En 3     | 48, v.1 | 6        | 56, v.4       | 5, 6     | 57, v.3 |
| M 2      | " v.1   | 4-6      | 52, v.1 | 7        | 57, v.2       | 7        | " v.4   |
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NEW YORK STATE EDUCATION DEPARTMENT

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Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co. N. Y.  
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— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonian of New York, Ireland and the Rhineland.
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- 3** Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co. N. Y. 128p. 9pl. Oct. 1900. 80c.
- 4** Peck, C. H. N. Y. Edible Fungi, 1895-99. 106p. 25pl. Nov. 1900. 75c. This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.
- 5** Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. \$1.50, cloth.
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- & Clarke, John M. v.8, pt1 Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16+367p. 44pl. 1892. \$2.50.
- & Clarke, John M. v.8, pt2 Paleozoic Brachiopoda. 16+394p. 84pl. 1894. \$2.50.
- Catalogue** of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. O. 1853.
- Handbooks** 1893-date. 7½x12½ cm.  
In quantities, 1 cent for each 16 pages or less. Single copies postpaid as below.
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- Maps.** Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum bulletin 15 and the 48th Museum Report, v. 1. 59x67 cm. 1894. Scale 14 miles to 1 inch. 15c.
- Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form* \$3; *mounted on rollers* \$5. *Lower Hudson sheet* 60c.  
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**Geologic map of Paradox Lake quadrangle**

## **New York State Museum**

The New York State Museum as at present organized is the outgrowth of the Natural History Survey of the State commenced in 1836. This was established at the expressed wish of the people to have some definite and positive knowledge of the mineral resources and of the vegetable and animal forms of the State. This wish was stated in memorials presented to the Legislature in 1834 by the Albany Institute and in 1835 by the American Institute of New York city and as a result of these and other influences the Legislature of 1835 passed a resolution requesting the Secretary of State to report to that body a plan for "a complete geological survey of the State, which shall furnish a scientific and perfect account of its rocks, soils and materials and of their localities; a list of its mineralogical, botanical and zoological productions and provide for procuring and preserving specimens of the same; etc."

Pursuant to this request, Hon. John A. Dix, then Secretary of State, presented to the Legislature of 1836 a report proposing a plan for a complete geologic, botanic and zoologic survey of the State. This report was adopted by the Legislature then in session and the Governor was authorized to employ competent persons to carry out the plan which was at once put into effect.

The scientific staff of the Natural History Survey of 1836 consisted of John Torrey, botanist; James E. DeKay, zoologist; Lewis C. Beck, mineralogist; W. W. Mather, Ebenezer Emmons, Lardner Vanuxem and Timothy A. Conrad, geologists. In 1837 Professor Conrad was made paleontologist and James Hall, who had been an assistant to Professor Emmons, was appointed geologist to succeed Professor Vanuxem, who took Professor Conrad's place.

The heads of the several departments reported annually to the Governor the results of their investigations, and these constituted the annual octavo reports which were published from 1837 to 1841. The final reports were published in quarto form, beginning at the close of the field work in 1841, and 3000 sets have been distributed, comprising four volumes of geology, one of mineralogy, two of botany, five of zoology, five of agriculture, and eight of paleontology.